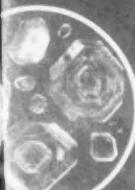


How To Control Germany

CHEMISTRY

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1944



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★ A SCIENCE SERVICE PUBLICATION ★

Demobilize Chemists to Create Jobs

• RETURN THE CHEMISTS in the armed forces to the jobs they can best do for the nation and the world—which is working at chemistry. Use chemists for chemistry and make jobs for the returning soldiers.

We join the plea of the American Chemical Society that the scientists and technologists should be released from Army service now so that they may return to industry and create jobs for the service men who will be demobilized when the war ends.

Industrial and Engineering Chemistry, the ACS publication, states that "if the 12,000 to 15,000 professional chemists and chemical engineers now in uniform are released promptly, they will help to create the jobs that G. I. Joe confidently expects to be here when he returns, perhaps in a ratio as high as 100 to 1."

Most of these men are not engaged in chemical work of any kind, and they are "desperately needed" in industry.

"These men never should have been taken out of the production army and away from research," it is stated.

England, Canada, and Russia did not permit their trained technologists to be inducted into the military forces and, because of this farsighted policy, these countries will have immediately available a well-trained, well-staffed body of technologists to meet postwar requirements.

"We, on the other hand, have drafted bona fide students of chemistry and chemical engineering and many of the younger instructors and assistant professors of these subjects despite the fact that it takes between seven and nine years to turn out a chemist or chemical engineer and several additional years to train men to teach in these fields."

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Chemistry Can Control Germany

• OUR BOMBS have smashed most of Germany's essential chemical industry used for war purposes. The plants making synthetic oil, manu-

facturing explosives, refining metals, and producing a thousand other necessities of war and peace are being destroyed as a part of the great United Nations offensive.

• *PHOTOGRAPH SHOWS U. S. Army bombers of the 8th Air Force leaving a chemical factory of the Focke-Wolfe company where metals used in Nazi planes are refined. The factory is hidden beneath the cloud of smoke from fires started by the bombs. Later photographs showed that it had been all but obliterated.*

As the war in Europe progresses toward the inevitable downfall of the Nazi regime and the defeat of Germany, there is widespread discussion as to the best way of assuring that Germany, however constituted on a postwar basis, will not have the means for creating a Third World War.

The proposals range from the idea of making Germany an agricultural nation, bereft of heavy industry with its population on a subsistence level, to an actual rebuilding of some of

the war-devastated heavy industry to provide for the normal peacetime needs of the population and to enable the payment of reparations. Heavy industry means, of course, industry that is essentially chemical in nature: metals, oil, chemicals, etc.

Whatever the extent of the proposals, there is general recognition of the basic character of the many chemical industries in the German economy and ability to prepare for or wage war. Control of Germany will, of necessity, be chemical in nature to be effective.

How to control Germany after victory has presumably been discussed at the recent Dumbarton Oaks and Quebec conferences, and plans, attributed to the Treasury Department, to the State Department, and to the War Department, have been reported in the daily press.

The Morgenthau or Treasury plan supposedly gives heavy industry machinery in the Ruhr to neighboring countries as indemnity for devastation imposed by the Germans, and provides that Germany become a light-industry-plus-agriculture economy.

The other plans are reported to provide that industry be kept going but that it be controlled. All plans, of course, provide for disarming and occupying Germany.

"The idea of turning a nation of some 80,000,000 people, in fact the most industrialized nation in Europe, into an agricultural country exclusively is utter nonsense." This is the editorial opinion of Industrial and Engineering Chemistry, considered to express the official opinion of the American Chemical Society. Di-

rect supervision of German industry by scientifically trained individuals to detect and prevent use of science and industry for war purposes is advocated.

Dr. James B. Conant, Harvard's chemist-president, would compel the transfer of Axis industry and the total liquidation of Germany's heavy industry "even if these measures require a reorientation of the economic balance of the world." He would also have technical experts watch German and Japanese industry to keep it from preparing new weapons secretly.

Four steps that would afford ample insurance against Germany's waging future war have been put forth by the presidents of five national engineering societies. Instead of indiscriminate destruction of German industry, the engineers' proposal contemplates stripping Germany of synthetic oil capacity, eliminating the bulk of its synthetic nitrogen capacity, halving steelmaking capacity to prevent production of war materials, and eliminating aircraft plants and equipment.

"The control of Germany and Japan" is the subject of a Brookings Institution study reported in a book of this title by Harold G. Moulton and Louis Marlio (Brookings Institution, \$2).

Germany is deficient in a large number of minerals which are indispensable for war purposes and which would seem to afford a means of control. But the Brookings Institution experts find that to control Germany by means of mineral sanctions would encounter four principal difficulties. Mineral production is widely distributed throughout the

world and supplies of minerals could be imported by Germany for many countries. They could be smuggled into Germany easily because of the many rail connections into the country and the small volume needed of many of the minerals. Substitutes of many minerals can be developed as undoubtedly has been the case during the present war. And then there is the difficulty of determining the true normal peacetime requirements.

Iron ore, 80% of which is imported into Germany for normal requirements, might be limited, but the experts see other countries suffering because of lack of this German business. Moreover, there is the possibility that Germany can exist on the exploitation of low-grade iron ores within its own boundaries.

Since nearly all German aluminum ingots are made from bauxite of which Germany has no deposits, that mineral might be controlled, but use of other raw materials and processes for aluminum production are so likely, in the opinion expressed, that bauxite control would give precarious security.

It would be next to impossible to prevent the accumulation of oil supplies for war purposes by controlling imports, the study declares.

The possibilities of preventing rearmament through the supervision, control, or elimination of a few key industries appears to be more attractive to Dr. Moulton and Mr. Marlio.

While the destruction of the iron and steel industry would produce serious economic consequences both in and outside Germany, an alternative to the destruction of metallurgy

would be a substantial reduction in the capacity of this industry. And the control of alloy steel, of special military importance, is suggested as a practical possibility.

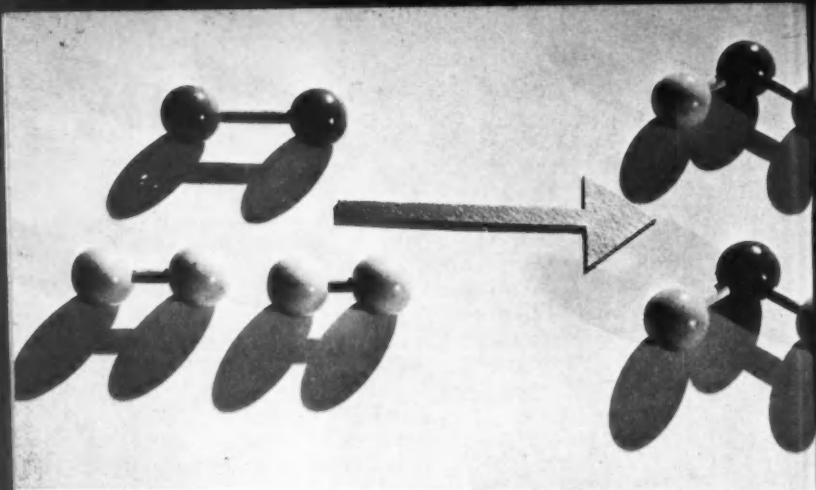
Aluminum's production, and use might be curbed, it is suggested, by the suppression of aluminum ingot production, which because of the necessity of electric power in large quantities is considered feasible. The control of magnesium, the other light metal, presents great difficulties because of plentiful raw material and relative ease of production.

Complete destruction of the chemical industry is considered impractical because of its need for peace and the difficulty of administrative control.

To limit petroleum for possible war use, the prohibition of synthetic oil plants is suggested, but prohibition of nitrogen and hydrogen production is not suggested because of their need in normal industry and agriculture.

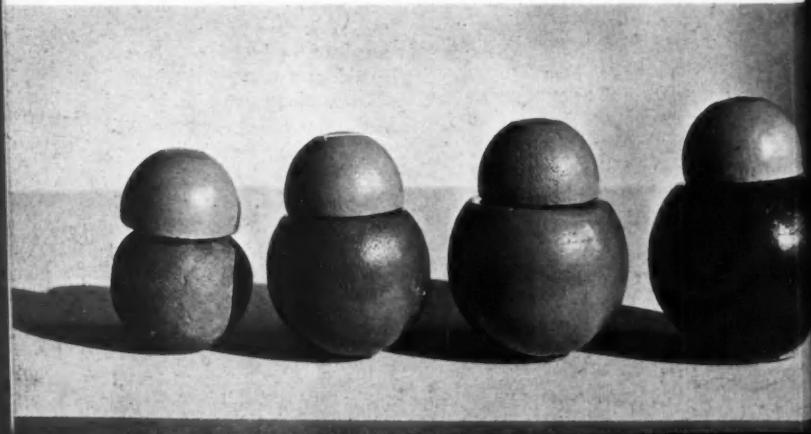
Prohibition of commercial as well as military aviation, including individual private flying, is a part of the Brookings plan as it is of most other suggested plans.

The electric power industry could bear much of the burden of control, the Brookings report emphasizes, if large power plants were prohibited within Germany and needed power were sent over high tension lines into Germany from neighboring countries. Thus with the throw of a switch the many industries dependent upon electric power could be controlled from outside the country, an invisible control that would be relatively less disturbing to the German public.



• **WATER (above).** The student accounts for all the atoms he starts with in the model and sees that $2H_2 + O_2 \rightarrow 2H_2O$.

• **THE HALOGEN FAMILY (below)** put on their hydrogen caps and turn into acids before your eyes. From left to right we have: hydrofluoric, smallest because fluorine is the lightest of the halogen group of elements; hydrochloric, larger because chlorine is next in atomic weight; hydrobromic, as bromine is still heavier; hydriodic, whose dark color might symbolize the metallic properties which appear for the first time in iodine, heaviest of the common elements in this group. Note that the same hydrogen appears in all the models.



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Models Show Invisible World

Photography by FREMONT DAVIS.

• MODEL ATOMS that can be seen and handled make the idea of these ultimate building blocks of nature more real to students, professional chemists, and those who just want to know.

Shapes and sizes of the built-up molecules emphasize the fact that differences in structure make differences in properties. Contrasting colors, sizes, shapes and textures of the models may be utilized to bring out likenesses and differences among the elements and compounds. Formulas and reactions become concrete problems when every given block must be used up on the other side of the equation and every valence peg fitted into a hole in an atom.

To show how the chemist's atoms combine to form molecules is the aim of several sets of blocks now on the market, or to be offered as soon as materials are more plentiful. In one

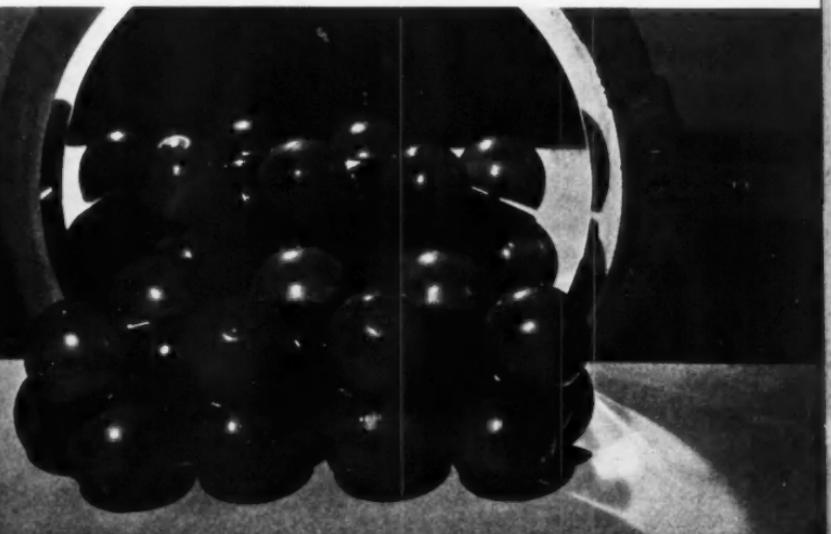
set, the sizes of the blocks vary to show differences in atomic weight. Shapes are also elaborately varied to let the atoms pack together. In another set, which emphasizes quantitative valence, the manufacturer cleverly gets around the difficulty of showing the double bond by using springs, which curve, instead of stiff pegs.

The Editors of CHEMISTRY have experimented with models which may be made up from easy-to-get materials.

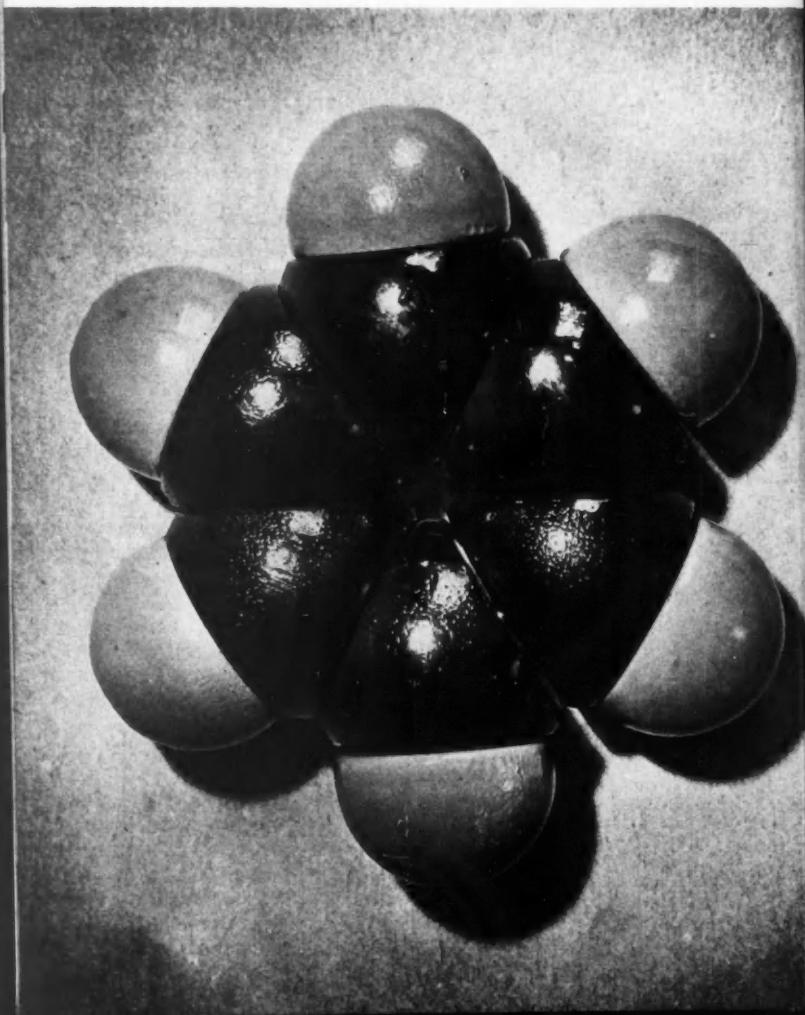
• *COMMERCIALLY obtainable models have been used to show a long carbon chain with attendant hydrogen atoms, a homologue of methane,*



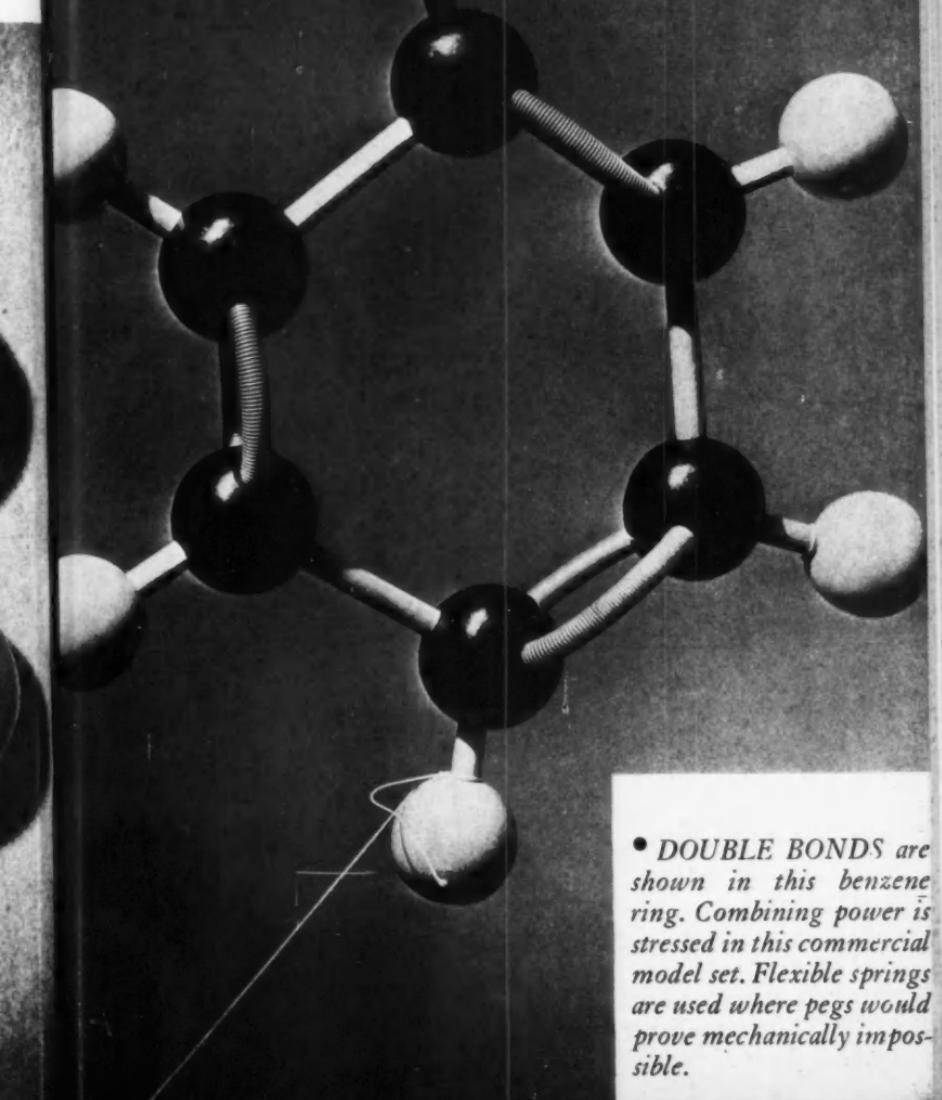
The hand mirror gives a rear view.



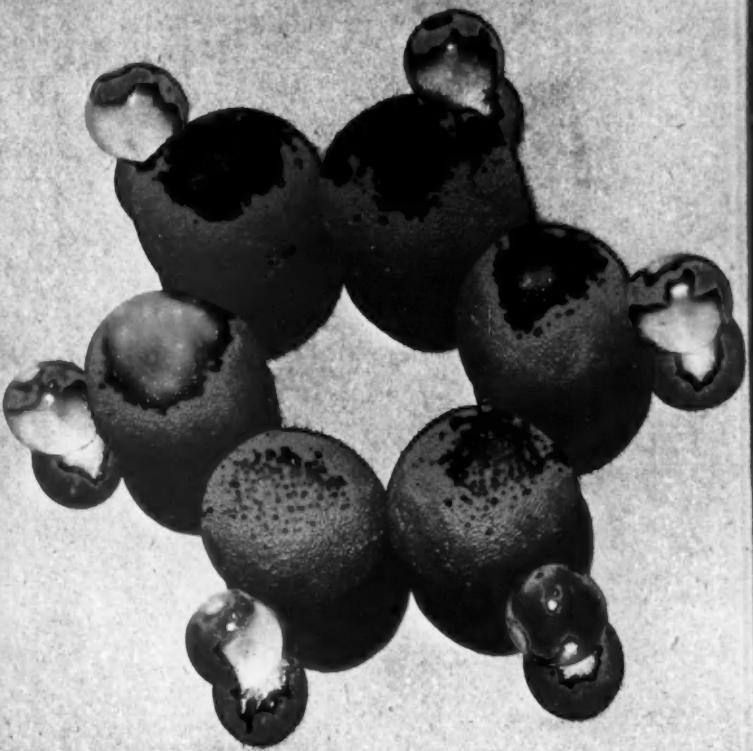
• C_6H_6 . This benzene ring is compact. Its carbon atoms fit closely together, to symbolize the stable structure of the compound. Atom models in this commercial set emphasize unity of the molecule. Valences are represented by small pegs fitted into specially spaced holes in the blocks.



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• DOUBLE BONDS are shown in this benzene ring. Combining power is stressed in this commercial model set. Flexible springs are used where pegs would prove mechanically impossible.



• JUST MARBLES AND CLAY. Contrasting textures illustrate the contrasting properties of the elements which go to make up the benzene ring in this home-made model. Clay suggests the earthiness of carbon, small glass marbles symbolize the ethereal quality of hydrogen. Materials from the toy department of the local 5 & 10.

Important Messages to Chemists

Essences of Addresses Before American Chemical Society

When the American Chemical Society meets as it did recently in New York, leaders in chemistry and public affairs give their views on matters of science and world affairs. Briefed for busy readers are some of the highlights of these speeches at the 108th A.C.S. meeting:

Conant Urges Scholarships

"In every section of the entire area where the word science may be properly applied, the limiting factor is a human one. We shall have rapid or slow advance in this direction or in that depending on the number of really first class men who are engaged in the work in question. The future of science in this country will be determined by our basic educational policy."

So declared Dr. James B. Conant, president of Harvard University and chairman of the National Defense Research Committee, in his address of acceptance of the Priestley medal of the American Chemical Society, awarded him for his outstanding work with the Council and, in association with Bernard M. Baruch, for the early wartime study of the American rubber situation.

"There are few who doubt," he said, "that both the future security of the country from a military standpoint and our continued prosperity as an industrial nation are closely linked with the proper support of scientific research and technical development."

"I am going to be bold enough,"

he added, "to make a specific suggestion that the federal government institute a national scholarship program for young men who give promise of becoming leaders in science and technology."

Dr. Conant would have these scholarships given to high school graduates through non-political committees in each state. They would include support on a modest basis through four to seven years of further education.

Recipients of these scholarships would agree, in return for the opportunity thus provided, to make themselves available in time of national emergencies for national service under whatever conditions the government should then set.

There are persons in this country who feel that drastic changes must be made in the organization of applied science, he stated, in the direction of more centralized control, more planning, and more direct intervention by the government.

"It would be my contention," he added, "that experience demonstrates that for the most effective scientific advance in the applied fields one must have keen rivalry and competition between a number of strong and independent groups. In each industry one might hope that at least half a dozen industrial laboratories would be carrying forward competitive lines of research and development."

Dr. Conant warned industrial laboratories against the danger of

their picking off for their work valuable men on university research and teaching staffs. "Remember that you are dealing in your laboratories with the application of science; you must look to the universities for the fundamental advances which you later are to apply. Secondly, you must each year look to the universities for trained men. Therefore, if you raid the university staffs and pick off the promising young professors for your work, you are endangering your greatest assets."

Midgley Accents Youth

"For genius and display, take youth; for cold calculation and planned execution, take age." This is the conclusion of Dr. Thomas Midgley, Jr., president of the American Chemical Society, in his presidential address at the 108th meeting of the Society held in New York.

Dr. Midgley's theme was the need of young men in science research and their necessity as shown by a recent study of the age factor in discovery and invention.

"The extension of life, resulting from the application of those principles regarding disease, developed nearly a century ago, has produced a condition in society whereby too many men are being kept in service beyond the years when previously they would have been eliminated." Dr. Midgley said, "This is particularly true in those activities requiring originality for scientific progress. Their retention is denying advancement to younger men at the very age when these younger men may be expected to be entering those years

when their maximum efficiency will be attained."

As evidence of youth's greater creativeness, Dr. Midgley cited an unpublished Patent Office table of important inventions, ranging from the steam engine by Watt to the airplane by the Wright brothers.

Of these inventions, 85 in number, 46 were by men 35 years old or less, 58 were by men under 40 years. Many of the inventions were by young men in their twenties. Most of those by men over 40 were men who had not yet reached their fiftieth birthday.

Dr. Midgley explained that he does not mean that men over 40 are of no use to society, for, he said, "it is too evident that they are. But their usefulness is distinctly of a different nature from the usefulness of youth. Youth is original and creative, while age is simply experience. Both are essential elements on any team that is to make for lasting progress. I am not complaining that we have old men in active service; but I do complain about having old men in young men's places."

Baruch Lauds Genius

The need to make greater use of "trained, scientific minds" in solving national and international problems of economics, politics and social matters was stressed by Bernard M. Baruch before the American Chemical Society.

The completion of the rubber program was a miraculous achievement of American industry, Mr. Baruch declared. Above all, the genius of the American chemists, scientists and draftsmen was responsible.

"I will not attempt here," he said, "to recount the astonishing achievements of scientists in chemistry, metallurgy, electronics, radar, television, medicine and surgery; how they have brought new horizons of adventure to the human millions of the present and future generations, how their activities have produced new material comforts and opened up fields that will give widening employment for many years to come.

"There is, however, one point I would like to stress, one that profoundly impressed me and that is the need of a greater use of trained scientific practical minds to help solve the many economic and social problems that face us. A trained, and

mind you I say trained, scientific researcher thinks only of the object he has before him, not of any ideology, not of himself, not of his publicity, not of what anybody thinks of him or his associates, not of another job but only of one thing: What do the facts justify?

"How helpful it would be if we could have more trained minds to see errors, to pass judgment and guide action before it is too late. So I hope that in the future even in the fields of economic, political and social matters, national and international, more of these trained scientific minds, these experienced searchers after facts, truths and realities will be asked to help solve them."

Design For Fighting Postwar

• POSTWAR WARS must still be fought by mankind, Dr. Harlow Shapley, director of Harvard College Observatory, declared in the annual Phi Beta Kappa address before the American Association for the Advancement of Science. They will be fought, not against the tyranny of known and tangible dictators like Hitler and Hirohito, but against the tyranny of the unknown, and if we are to win we must put into them effort and treasure comparable to the sacrifices we are making now.

Two contradictory and amazing situations exist in America at the present time. One is the fact that Americans are profiting from the war both materially and in social and intellectual ways. The other is the fact that all Americans want the war to end as quickly as possible.

This seeming paradox, as Dr. Shapley sees it, is explained not only by our fears of what may happen as a consequence of continued fighting but by our innate antipathy to war as such.

"This antipathy," he said, "is a characteristic that has been slowly bred into man by centuries of ethical teaching. When he is rational, man almost instinctively believes that peace is good, war is evil and that peace is the concomitant of desired individual liberty and democratic society.

As specific examples of enemies to be attacked in the postwar wars, Dr. Shapley pointed out illnesses that age and kill men and women before their time. He indicated five as particularly evil: cancer, mental derangements, arthritis, and the dis-

eases of the circulatory and respiratory systems. He stated that in one 10-month period 25 years ago four times as many Americans were killed by influenza as died in the whole of World War I. As against the 300 men killed per day during the critical stage of the Normandy invasion he cited 400 deaths a day from cancer in a war that never ends.

Exhausting and debilitating as are

the after-effects of a shooting war, they have no worse effects on nations than persisting illiteracy and low educational standards. Nor do people need to await an authoritarian suppression of "dangerous thoughts." A deadening cultural uniformity is one of the dangers inherent in the very unity which we are seeking as a means to peace.

Catalysts Are Key Weapons

• CATALYSTS are the real key weapons that decide the course of wars, Prof. Hugh S. Taylor of Princeton University declared in his address as retiring vice president of the section on chemistry of the American Association for the Advancement of Science at Cleveland.

Chemists nearly won the first World War for the Kaiser because they had mastery of two catalytic processes, the utilization of coal tar in explosives and poison gases and the synthesis of nitrates out of the air, Prof. Taylor pointed out. Chemists are winning the second World War for the United Nations through their mastery of catalytic processes that give us an abundance of high explosives, hundred-octane gasoline, synthetic rubber, nylon and plastics.

A catalyst is a substance that promotes a chemical reaction without being directly involved or used up itself. Some catalysts, such as those that weld together the big molecules of synthetic rubber or nylon out of smaller molecules, are active in promoting unions—they are the marry-

ing Parsons of chemistry. Others, like those that split heavy petroleum molecules into the lighter ones of aviation gasoline, are specialists in taking things apart—they are the divorce lawyers. But the catalysts themselves remain chemical bachelors.

One of the great successes of recent catalytic chemistry, Prof. Taylor pointed out, has been the production of toluene from petroleum. Toluene is best known as the raw material for TNT—which is chemical shorthand for tri-nitrotoluene. During the first World War, toluene could be made only from coal tar, and cost more than a dollar a pound. Now, thanks to the catalytic cracking of petroleum, it costs only a few cents a pound.

Besides being useful in a high explosive, toluene has great potential value in the production of super-gasolines, for which it will be available after military requirements are met. One grade of aviation fuel in which it is used has an octane rating of 125.

Synthetic Rubber Production Surpasses Prewar Imports

Rubber from Chemical Factories

by MARTHA G. MORROW

• ALL AMERICA MAY look forward to a plentiful supply of rubber products once again, thanks to man's ingenuity. An adequate supply of girdles, garters and similar products made of synthetic elastic thread will be in stores, possibly by January. Rubber heels to help stretch shoe coupons will once again be of the best quality. And if you are caught wearing your best shoes in the rain, overshoes can probably be procured at a neighboring store. Even tires for automobiles are promised for the not-too-distant future.

Synthetic rubber in the meantime is taking care of our war needs. Supplies and equipment are rolling to our fighters on synthetic tires. Bullet-sealing fuel cells and hose, landing boats, gas masks, life rafts, barrage balloons, wire and cable, and a multitude of similar articles are going to the front—thanks to synthetic rubber.

The United States uses more rubber annually than all other countries combined. When our natural rubber was cut off by the war, Uncle Sam was forced to search for other sources of rubber. But today synthetic rubbers are being made at a rate greater than that at which crude rubber was consumed in this country in any year prior to 1941. By the end of 1944 all synthetic rubbers will probably be made at the rate of 1,027,000 long

tons per year.

Approximately 86 per cent of the war-born synthetic rubber program is devoted to the production of GR-S—which stands for Government Rubber, type S (Styrene). Sometimes called buna S, this rubber is known as GR-S in this country because the American product differs from and is superior to the German buna S.

GR-S, most of which is used in making tires, is the type of synthetic rubber which most nearly resembles natural rubber. The materials from which it is made can be produced in large quantities at relatively low cost. They are butadiene and styrene. Butadiene is made either from petroleum or alcohol (which is one reason there is a shortage of whisky). Styrene is made from benzene (from coal tar) and natural gas, petroleum or alcohol. Large GR-S plants were built and are being operated for the government by such rubber companies as U. S. Rubber Company, Firestone Tire and Rubber Company, B. F. Goodrich Company, and Goodyear Tire and Rubber Company.

Neoprene was the first successful synthetic rubber produced in commercial quantities. Developed by E. I. du Pont de Nemours & Company, it can compete with natural rubber in resiliency, elasticity and resistance to abrasion. It resists deterioration by

oils and other substances that destroy natural rubber very quickly. Made from coal, limestone and salt, it is more expensive than GR-S or butyl, but has a place of honor in the government program as an outstanding special-purpose rubber.

Next to buna-S and Neoprene, buna-N is the rubber most widely used in this country. Made from petroleum, soap, natural gas and air, buna-N differs from GR-S largely in the fact that the butadiene, instead of being combined with styrene, is copolymerized with acrylonitrile, a product made from ethylene (from petroleum) treated with hypochlorous acid and sodium cyanide. The principal synthetic rubbers included in this group are Goodrich's Hycar, Goodyear's Chemigum, Firestone's Butaprene, and Perbunan of Standard Oil Company of New Jersey.

Butyl rubber may eventually be one of the most useful synthetic rubbers for general purposes, but at present it is restricted because of small scale manufacture. Its impermeability to gases is excellent and it is partly because of this that butyl is resistant to mustard gas and is one of the few materials resistant to Lewisite. This property also makes it particularly desirable for tire inner tubes.

Butyl rubber, the production of which is controlled by Standard Oil of New Jersey, depends upon the petroleum industry for its materials, the two principal ingredients being made from oil.

Large quantities of isobutylene, an oil refinery product, are mixed with small amounts of isoprene, a chemical which is found combined in nat-

ural rubber, but can also be made from petroleum or turpentine. It is also possible to make butyl by mixing isobutylene with small amounts of butadiene, a by-product in petroleum cracking.

Development of artificial rubber in recent years has been motivated by different aims in various countries. In Europe, natural rubber supplies have been curtailed, and artificial rubber was needed as a substitute, hence cost became a secondary consideration.

In the United States the need for a substitute for natural rubber was not so important. Instead, the effort has been more to find a synthetic material which would have advantages over the natural product and so justify the increased cost. But war suddenly changed this situation.

Synthetic rubber is similar in its chemical structure to natural rubber, but is not identical with it. Many different kinds of synthetic rubber have been produced. Both synthetic rubber and natural rubber are composed of giant molecules consisting of long chains of carbon and hydrogen atoms. A single molecule of natural rubber is thought to contain about 75,000 atoms of carbon and 120,000 of hydrogen — altogether 195,000 atoms.

No one knows exactly how these are put together by nature to form a rubber molecule. No wonder it is so difficult to try to duplicate this complex material in the laboratory. In the giant rubber molecule, a pattern consisting of several atoms is repeated thousands of times. Such patterns are called polymers and the

process of causing them to form is polymerization.

Most of the artificial rubbers can be vulcanized, as can natural rubber. This process consists of adding sulfur atoms to the chain. These combine with loose chemical linkages present in the molecule. Neoprene, in contrast with the other synthetic rubbers, does not require sulfur for vulcanization.

An advantage claimed for butyl rubber is that it has just enough loose linkages to combine with the necessary sulfur, and then they are all used, so none is left to combine with oxygen from the air. It is this oxygen combination that causes the deterioration of natural rubber when exposed to the air.

More than four-fifths of our present synthetic rubber production is GR-S. It mixes readily with other rubbers, including natural, so that it blends well in the tire compounds commonly used today. It has high resistance to abrasion, which means that it wears well—as well as natural rubber. But it does not have natural rubber's ability to take endless bending and bending.

On the average the mixture used in making GR-S is about three-fourths butadiene and one-fourth styrene. The ingredients are mixed in big pressure vessels into which water, soap, styrene, butadiene and "seasoning" chemicals are pumped. The mixture is cooked for about 16 hours, the ingredients being continually mixed all the while. The chemicals gradually unite to form the synthetic rubber GR-S.

A small part of the raw materials,

which does not polymerize in the time allowed, is separated and piped back to join the supply lines. The rest, in the form of milky latex, is run into the coagulating vat with some brine and acid, and stirred to form curds of rubber. These are carried through a wringer which squeezes out the liquid. They then go through a drier, later being pressed and baled for shipment.

Synthetic rubber is not the development of any one man, or even of any one nation. Over a period of years important contributions have been made by chemists of Great Britain, France, Germany, Russia and the United States.

In 1826 Michael Faraday helped establish the fact that the chief constituent of rubber is hydrocarbon, and that natural rubber is composed of a multiple of five atoms of carbon and eight of hydrogen.

Grenville Williams broke down natural rubber by heat in 1860 and derived from it a liquid, named isoprene, which had the same chemical composition as rubber. About 20 years later G. Bouchardat had the "bold idea" that isoprene was the foundation stone of rubber, an observation which led to our present synthetic rubber industry.

The isoprene used by Bouchardat was obtained from rubber. In 1892, Sir William Tilden made isoprene from turpentine. After standing in a bottle for a while, large yellow pieces formed which somewhat resembled rubber. Though the material was useless, it was the first time synthetic rubber had been made.

Originally the goal of those work-

ing in the field of synthetic rubber was to synthesize a product that would equal natural rubber in those properties that have contributed to make rubber such an important structural material.

The more recent trend, however, has been to synthesize materials closely resembling nature's product in some respects, but surpassing it in others. Buna-N, for instance, is for all practical purposes immune to oil.

Neoprene will not burn. The future of the rubber industry depends largely on the things a product will do which natural rubber cannot.

If you would like to have samples of four typical types of synthetic rubber, you can secure the Rubber Unit of THINGS of science, a kit prepared by Science Service, by sending 50 cents to Science Service, 1719 N Street, N.W., Washington 6, D.C., and asking for Things unit No. 46.

Plentiful High Octane Fuel Foreseen

• HIGH OCTANE aviation fuels may be more plentiful after the war because of a new development in the design and operation of a smaller, less expensive unit for carrying out the necessary catalytic cracking process to obtain these fuels from petroleum products. Small refiners, who make up the greater part of the petroleum refining industry, will be able to use this new unit so that the production of 100-octane and other high-octane fuels will no longer be confined to big refineries with expensive plants.

The new development is a result of work by scientists of the Universal Oil Products Company, based on a fluid catalyst cracking process originated by the Standard Oil Company of New Jersey.

Two processes for cracking petroleum products to obtain high-quality fuels are catalytic cracking and thermal cracking. In either the original hydrocarbons are broken down to

yield other products. A catalyst is a substance added to assist the process, but it itself remains stable and is recovered when the process is completed.

In catalytic cracking the relative yields of gases and the yields and types of hydrocarbons produced are different from those produced by thermal cracking. Higher percentages are obtained of those that contribute to superior anti-knock qualities.

The fluid catalyst cracking process employs an entirely new chemical technique. In it the catalyst is mixed with the hydrocarbon vapors as both pass to the reaction zone. In the older process the vapors are passed through a bed of catalyst. The fluid process is so flexible that it can operate at a great variety of cracking temperatures, giving the process the widest adaptability to produce aviation gasoline, toluene for TNT, or high-grade motor fuel.

**Powder for Rockets Must Burn
Rapidly and Research and Manufacture
Is One of Many Problems**

Rockets Become Major Weapon

• ROCKET WEAPONS, now in general use, promise to play an even more important role as the war progresses.

Most of the U.S. Navy's rocket weapons have been developed in an extensive rocket research program conducted by the Navy, a committee of scientists known as the National Defense Research Committee, and engineers at the California Institute of Technology.

To date, rockets have been used in the invasions of North Africa, Sicily, Italy and France, in the island seizures in the South Pacific. They have become standard equipment for all amphibious operations, and in anti-submarine warfare.

New air-borne rockets as armament for carrier-based and amphibian planes have been used successfully against German submarines in the Atlantic and against Jap shipping and land installations in the Pacific.

Research on rockets was concentrated at the California Institute of Technology in September, 1941, under contract with the Office of Scientific Research and Development and under the technical supervision of the National Defense Research Committee.

At that time, rockets were not by any means new weapons of war. The British had had experience with artillery rockets early in the nineteenth

century but abandoned the idea in favor of rifled cannon.

Rockets have greater fire power and mobility than guns, and since they have no recoil they are particularly well adapted to installation on light landing craft, airplanes, and motor vehicles. Launching devices are cheap and lightweight.

The problems involved in rocket development are many and many involve chemistry. Perhaps the first is a suitable propellant—some form of powder that burns rapidly, generating a large quantity of hot gas. A satisfactory propellant material must have stability through a wide temperature range and a desirable rate of burning.

"Arming" devices for the fuses in rocket bodies present still another problem. Artillery shells, for safety in handling, have a device which keeps the fuse from operating until after the shell is fired. The release of this device is called "arming" the fuse. New mechanisms have to be worked out for arming the fuses of rocket projectiles.

Accuracy of fire presents another difficulty. All of these problems are being studied, and solutions are being found, at the California Institute's rocket research laboratories.

The most recent rocket developments must remain for the present in the realm of military secrets. The magnitude and importance of the

work can be seen from the fact that rocket research and development stands almost at the top of the list of manpower and materials priorities, and the fact that the Army and Navy have placed rocket production contracts totaling many millions of dollars.

In addition to conducting rocket research and development the California Institute of Technology also has a rocket manufacturing project. This project is one of the few manufacturing programs ever undertaken by a school of higher learning, in wartime.

Unraveling A Patent Tangle

An editorial in the New York Times, September 15, 1944

• SIX OF THE LARGEST oil companies of the country have transferred to the American Chemical Society the ownership of the Universal Oil Products Company, a property with a value that lies between \$10,000,000 and \$15,000,000. The income of about \$1,000,000 a year is to be spent for research in petroleum chemistry, chiefly by grants to universities, and any discoveries or inventions that may result will be available to the public without payment of any kind. Thus the Society becomes a philanthropic institution and the custodian of a large fund for research, and some of the patent controversies that have attended progress in petroleum refining will come to an end.

The history of Universal Oil Products has been a laudable history of research and of accomplishment. But the patents in which fruits of research were disclosed were so many bones of legal contention. Indeed, so in-

volved was the system of licensing and cross-licensing that six important licensees decided to end their difficulties by acquiring the company. Though the original Gordian knot was thus cut, new knots were tied by new patents with new legal complications. Moreover, patent pools have been under fire for some years, with the prospect that anti-trust suits would eventually be added to patent troubles. Even if the six companies had decided to administer the patents in the public interest, they would undoubtedly have been charged with favoritism in making grants for research on a purely philanthropic basis. There was only one solution, and that was to transfer the whole property to an organization which had no commercial interest of any kind. Under the auspices of the American Chemical Society research should go on as intensively as ever, with benefits to the oil industry and the public.

Heating, ventilating, and air-conditioning research projects, to be undertaken in seven universities with funds provided by the American Society of Heating and Ventilating Engineers, will cover postwar possibilities.

**U. S. Controls Production
of Light, Non-Burnable Gas**

Helium, The Sun Gas

by ROBERT N. FARR

• ONE SCIENTIFIC research baby, born afighting in the first World War, fighting again in this war, now looks forward to an even more useful career in peacetime. It is helium, the lightweight among non-burnable gases.

Uncle Sam has a world monopoly on the large-scale production of this gas, known to science as chemical element No. 2. So rare was helium in 1917 that it sold at a rate of \$2,500 a cubic foot, but it is so plentiful now that Uncle Sam extracts millions of cubic feet of it at less than a cent per cubic foot.

No one will ever see helium gas. It is completely colorless, odorless and tasteless.

This "invisible gas" lifts Navy blimps, used to ferret out Nazi U-boats. It carries meteorological balloons to stratospheric altitudes, gaining weather data vital to the success of military and naval operations. Deep beneath the sea it helps reduce the danger while divers do their work. In war plants it helps curb explosion hazards. Doctors use it in treating respiratory diseases.

Uncle Sam controls the production and distribution of helium through the Department of the Interior, with the Bureau of Mines actually drilling the gas wells, and building the plants in which helium

is extracted from the natural hydrocarbon gases, piped from deep beneath the earth's crust.

Most helium-yielding gas wells are in the southwestern part of the United States, particularly in Texas, Kansas and New Mexico.

Helium was named "the sun gas" because it first was detected in the sun's spectrum in 1868 as a strange new yellow line. Later it was discovered on earth in certain minerals, and more recently in natural hydrocarbon gases.

No helium is being produced commercially from any source outside the United States today. However, there is a potential yield of 200,000 cubic feet a day from the gas that pours forth from boric acid fumaroles in Italy. Canada also has some natural gases that contain a small percentage of helium.

At the close of World War I the desirability of helium as a lifting agent was well established, its value lying in the fact that while its lifting power is 92 per cent of that of hydrogen, lightest of all gases, it forms no dangerous explosive mixture with air, which hydrogen does.

Twenty-five years of research has barely scratched the surface of the possibilities for the industrial, scientific, and medical uses for the "sun gas." Helium is now available in

large quantity for research and commercial applications.

A list of present and possible future uses of helium includes use as a food preservative, an extinguisher for fires, a cleansing agent to remove impurities from molten metals, in the development of explosion-proof motors, in refrigeration to produce ultra-sub-zero temperatures, in optical instruments, and as a tracer element to determine migrations of underground deposits of natural gas.

New techniques of studying weather require the use of large balloons to carry heavy meteorological equipment to high altitudes. Because it explodes and burns, the use of hydrogen to lift these balloons proved to be quite dangerous, therefore the U. S. Weather Bureau now uses helium to help get weather predictions.

In the medical field the sun element has been used for more than 20 years in experiments and in actual practice in preventing caisson disease, or "bends," in deep-sea divers, tunnel workers, and others forced to work in atmospheres of relatively high pressure.

The old method of using compressed air in deep-sea diving limited the depth to which a diver could safely go to little more than 250 feet. At this depth the increased oxygen made the diver lose part of his ability to think, and as a result he could work less than one hour at that depth. It also required up to four hours for the diver to return to the outside air in order to avoid the "bends," which is due to nitrogen bubbles coming out of his body tissues and collecting at his joints.

Dr. R. R. Sayers, director of the Bureau of Mines, and his associates worked with Navy Department personnel to develop a helium-oxygen mixture in deep-sea diving, thereby eliminating the nitrogen which may cause the "bends." By using this helium-oxygen mixture, the depth to which deep-sea divers can go has been greatly increased, and the divers are able to work at these greater depths for longer periods of time, returning to the outside air in a fraction of the time necessary where compressed air is used.

On the basis of somewhat limited experiments, it appears that the helium-oxygen mixture may be of value in preventing "sky bends," a complaint of flyers who go up to altitudes of around 30,000 feet. During descent from high altitudes nitrogen bubbles form in the body by fundamentally the same process that causes them to appear in deep-sea divers.

Ear trouble, the most common complaint of airplane pilots and passengers, can be relieved or prevented by inhaling a helium-oxygen mixture during marked changes in altitude of the plane, especially when descending.

Among other new medical applications of helium are the treatment of pneumonia, asthma and other respiratory diseases in which helium eases the burden on weakened lungs. Asthmatic patients frequently get relief almost instantly by inhaling a mixture composed of helium and oxygen. This is not considered a cure for asthma, but in many cases war-workers who suffer from asthma are enabled to keep on the job by taking

a whiff of the breathing mixture from time to time.

One of the newest uses of helium is in the heliarc process of welding magnesium. Helium acts as a shield to hold off the oxygen of the air and thus prevents the metal from bursting into flame. The blanket of helium not only smothers any tendency of the metal to ignite, but it makes the joint stronger and less susceptible to corrosion. It is also being used with steels and other metals to produce better welds.

Liquid helium may one day be employed to treat materials such as metals and plastics at extremely low temperatures. Although this field is still largely unexplored, the low temperature of liquid helium, in addition to its other characteristics, may have definite advantages over other cooling agents.

Since it is a better heat transfer agent, and of lower density than air, helium is used with large-capacity dynamo-electric generators to dissipate heat and reduce resistance to rotation of the armatures, thereby increasing the capacity of the generator.

Now used between the lenses of some optical instruments, helium gas curtails errors of vision because it has a low refractive index and high heat transfer. As a coolant, helium

used around electrical instruments prevents electric sparks from igniting explosive mixtures which may be present in the surrounding air.

Helium has the low density needed for penetration and chemical inertness to prevent compounding with hydrocarbon gases under high pressure. These characteristics may make helium desirable for use as a tracer gas. Pumped into one natural gas well, helium would indicate the movement of other gases if detected in greater volume or in the discharge from other wells in the field.

Many authorities on air transportation are convinced that the versatile role played by blimps in the present war will foreshadow lighter-than-air transportation in the post-war world, particularly in trans-oceanic commerce involving long-range flights. The increased safety, because helium will not burn, the increased comfort of passengers, and the greater payload may bring the return of big airships. Such a program would call for immense quantities of helium and would give the United States unchallenged leadership.

Experts in many fields predict that helium will be of great usefulness in the postwar years, and that it will become firmly entrenched as an essential element in the American way of life.

To conserve beef liver, now the chief food used in Georgia's fish hatcheries, the State Fish and Game Commission is experimenting with the use of fish refuse, such as shrimp heads, crab residue and discarded fisheries products.

A Bit of Chemical "Magic:"

Lumps Change Color In Water

by JOSEPH H. KRAUS, *Science Clubs of America Editor*

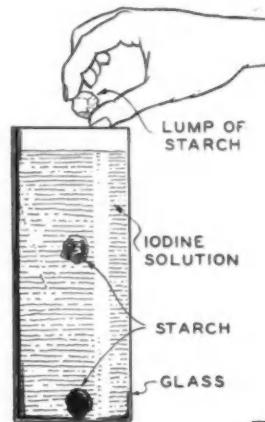
• ORDINARY LUMPS of laundry starch will undergo a rapid change of color when falling through water to which a few drops of tincture of iodine have been added. The color changes rapidly from light blue to dark blue, and by the time the lumps come to rest at the bottom they appear almost black.

This experiment is a spectacular demonstration of a rather common test for starch, and conversely, for iodine.

Fill a tall drinking glass or clear glass vase with tap water. To each ten ounces of water add six drops of tincture of iodine—the kind found in the home medicine cabinet. Stir the liquids. You will have a light amber-colored solution.

Select some large, flat pieces of starch from a box of laundry starch. Drop one of these into the iodized water and watch it as it falls. The lump of starch will change color rapidly. If it is not black by the time it reaches the bottom of the container, it will become black a moment later.

A recognized test for starch is to apply iodine to the material being tested. The production of a blue color denotes the presence of starch. Similarly, this also is a common test for iodine. If you suspect that iodine is present, add some starch and the resulting blue color will tell the tale.



SS

The compound formed is starch iodide.

Test Vegetables

Cut a square of ordinary potato and drop it into iodized water to see if it changes color. Using the same solution, test other vegetables. Also try prepared flour, spaghetti, a piece from an old starched shirt and another piece of shirt from which starch has been washed out. You might like to test several different kinds of paper for the presence of starch.

Put a single drop of iodine solution into a clean tumbler and add a teaspoonful of water. Test the solution with a grain of starch. Continue

to add a teaspoonful of water at a time, thus reducing the concentration of iodine solution. Inasmuch as each teaspoonful of water contains approximately sixty drops, you can

determine for yourself the extent to which the concentration of the iodine solution can be reduced until no further perceptible color change takes place.

Chemistry in the Kitchen:

Hints On Safe Dish Washing

• ANYONE WHO WASHES dishes, whether for the family in a private home, or in a restaurant, boarding house, tavern or other public eating place, could learn more about how to do this important job properly from a report by John Andrews, Sanitary Engineer, U.S. Public Health Service, in Public Health Reports.

Dishes, glasses, and other eating utensils that are not correctly washed may spread disease germs. There are signs, Mr. Andrews says, that the amount of disease spread in restaurants is increasing.

Dishes should first be scraped well to remove all food particles and preferably should be rinsed with water before the real washing is started. For hand dishwashing, Mr. Andrews advises a two- or three-compartment sink that is big enough for the job and has adequate drainboards.

The wash water should be heated to 110 to 120 degrees Fahrenheit, which is about as hot as the hands can stand. It should contain a sufficient amount of soap, soap powder, washing powder or whatever cleansing agent is used. In addition, the dishwasher must use plenty of "elbow grease." If there are a lot of

dishes to wash, the water will cool off during the process and the soap or other cleansing agent will get weaker. So the dishwasher must add more soap from time to time, keep the water hot and change it before it gets too dirty.

The washed dishes should be stacked in baskets with long handles so that they can be given a germ-killing treatment after washing. This can be done by immersing them in hot water or a chlorine solution or by other methods. If hot water is used, it should be at least 170 degrees Fahrenheit and the dishes should stay in it for at least two minutes. If chlorine is used for the germ-killing, the dishes should be rinsed first because chlorine is quickly depleted by soap or other cleansers and by organic matter that may be carried over from the wash water.

The dishes should be allowed to drain and dry before putting them away. If stored while still moist, the few germs that may still be on them may live and multiply quickly. If the water is hard, it may be necessary to dry the dishes with a towel to prevent water spots. The towels, of course, must be clean or they will put germs back on the dishes.

Superfuels to Win Pacific War and Reduce Costs of Post-War Air Travel In the Making in Our Chemical Plants

Better Aviation Gasoline

• BETTER QUALITY aviation fuels are now being developed that will reduce the operating costs for planes and at the same time will give improved performance. Intensive research is also being done to develop special fuels that will play a big part in winning the battle of the Pacific.

While facts and figures about these new fuels cannot be released at present, the general objectives are clearly defined.

The airlines spend several million dollars a year for fuel for their planes, and after the war, with the promise of increased flying, the cost of fuel will play an even bigger part in keeping the airline fares up. If a new aviation fuel that will give the same power on less fuel is produced commercially, your seat on a plane after the war may be less expensive.

The fuel that helped win the battle of Britain was one that obtained greater power from the same mixture of air and gas as was used prior to the war, resulting in better performance.

The big factor in the Pacific theater is range of operation. Petroleum technologists are now at work on a fuel that permits longer flights on the same amount of fuel. This fuel may help win the battle of the Pacific.

Going one step farther, science is endeavoring to create a fuel that combines the best qualities of the two fuels just mentioned, resulting not

only in greater range but also in better performance, on a smaller volume of fuel.

The chief limiting factor in aviation fuel performance at present is the tendency of most fuels to knock under conditions of increased power. This is the same kind of knocking that annoys you when you "gun" your automobile motor going up a hill. Knocking in an aircraft engine is dangerous, even to the extent of destroying the engine itself.

The power output of an airplane engine when operating on the lowest weight of fuel may be limited by knocking. To obtain maximum power, it is necessary to find ways to avoid this knocking. This is done by feeding to the engine more fuel than it needs to produce a given amount of power.

Therefore, while modern aircraft fuels permit engines of greater power to be built, they use up large amounts of fuel. The B-29 has four 2,200-horsepower engines. This and other great teams of engine and fuel power our attack on Japan today. At the same time these engines still employ uneconomical amounts of fuel for take-off, climb, and high speed.

Startlingly high amounts of fuel have been needed in Europe. A single bombing mission over Berlin from bases in Britain requires up to 3,000,000 gallons of 100-octane gasoline for 1,000 heavy bombers and their

escort fighter planes. This is about one-third of the reported total U.S. daily production of the high-powered aviation fuel.

The present consumption of aviation gasoline by our air forces is over 150,000,000 gallons a month in the theaters of operations only.

One squadron of 12 B-24's on a five-hour mission from the Palau Islands to bomb Mindanao might

use up more than 16,000 gallons of aviation fuel.

The need for a fuel that gives greater power with lower fuel consumption becomes apparent when you look at the longer distance supplies of gasoline have to travel to get to the Pacific theater. Almost every drop of fuel used by our fighters and bombers in the South Pacific has to be carried by boat.

Wet Strength Papers

• PAPERS THAT PROVIDE protection against water are old, their resistance depending on saturating or coating the original paper with a waterproof material such as asphalt or varnish which constitutes the real repellent. When subjected to water for prolonged periods, the fibrous portion of such papers loses its strength, resulting in rupturing of the protecting films.

True "wet strength" paper which, without a protective coating, retains up to 60% of its strength when water soaked, is now coming to market from numerous mills as the result of the development of resins which can be added to the paper pulp without other alterations in the paper-making process. Such papers even when thoroughly soaked, show great resistance against bursting, tearing and scuffing. These remarkable improvements are obtained by addition of from 0.5% to 3.0% of a new thermosetting resin which makes the fibres cohere more firmly when they are felted on the forming wire and subsequently dried.

Treated paper is not otherwise perceptibly altered in appearance, brittleness or even absorption. In fact, in order to distinguish it readily, the government specifications for shipping sacks require such paper to be marked with distinctive colored stripes. Sacks made with wet strength paper, or with plies of asphalt laminated wet strength paper, have made good as substitutes for textile bags for potatoes and for other vegetables, flour and sugar. Outdoor storage in such paper bags is often possible for products that would otherwise have to be housed.

For cleaning lenses, the Armed Services have soft paper tissues which not only hold together when wet, but are substantially lint-free. Individual paper towels for use in washrooms will stand wetting without coming apart in the hands.

Great improvements have been made in the manufacture of paper for charts and maps for our Armed Forces to avert disintegration by rain or seawater.

—From "For Instance"
(American Cyanamid Co.)

**Carbon and Silicon Join in Making
New Synthetic Fluids, Resins and Greases**

Silicone—New Wonder Plastic

by CAROLINE PARKINSON

• A NEW FAMILY of synthetic resins, called silicones, is giving waterproofing, flame-resisting service in planes, radios and other machines operating at the front. Released for civilian use, the new substances promise renewed life in electrical equipment of home and factory.

By crossing slippery organic compounds with the gritty components of sand and glass, the creators of silicones have produced a hybrid synthetic which is more stable than any of the insulating substances used before. From the silicon, or glass chemical side of its family, it inherits resistance to water, air and temperatures as high as 500 degrees Fahrenheit. From the organic side comes the ability to form resins, greases and fluids, for use in all kinds of machines.

Electrical equipment can now get a 400-year lease on life. Tests show that a trolley car motor with silicone insulation could be kept in continual operation for 3000 hours at 482 degrees Fahrenheit, which is equal to 400 years of service at the ordinary temperature.

Motors of the future will be small but mighty. A ten-horsepower motor, using featherweight silicone insulation, occupies no more space or weight than a three-horsepower motor with the old type insulation. Methyl chlorosilane is being used in

radio insulation, enabling a plane to make rapid dives into humid atmospheres without danger of short circuit from moisture seeping through. Many are the post-war applications of this water-repellent silicone.

Silicone oils which do not solidify at fifty degrees below zero Fahrenheit, and are still giving service at 400 degrees above, are now lubricating fighting machines.

Most people think of silica as the substance that gets between their toes on the beach, and goes into making a glass window pane or a piece of sparkling crystalware. Its new role in the formation of sticky, gluey resins, and in stop-cock greases comes as less of a shock, however, when it is known that silicon is the closest relative, chemically speaking, of carbon, and therefore it has many properties in common with the element around which most of the plastics, oils, and other organic compounds have been built heretofore.

The ability to link with itself and form long chain molecules, the property which makes carbon king of the entire field of organic compounds, appears in the three other members of its immediate chemical family—silicon, titanium and germanium. Carbon can form the longest chains, as many as 500 carbons linked together; silicon comes next. Then come titanium and germanium,

which have also been considered as constituents of new resinous products.

The new entrant into the backbone of organic compounds has the advantage of being the most abundant electropositive element on the earth's crust. Sand and various forms of quartz, rock crystal, amethyst, rose quartz, and milky quartz are all made of silica. Many of our common rocks contain silica.

The silicon compounds which man has found most useful before this are the forms used in concrete for building and in ceramics. It has taken a hundred years of laboratory research to utilize the rare qualities of organic-like silicon compounds in products such as those which have emerged during this war.

The first step in silicone chemistry is to get it into a form which will react with desired organic compounds. This is usually silicon tetrafluoride or silicon tetrachloride, analogous with carbon tetrachloride. It is made by passing chlorine over a strongly heated mixture of silica and carbon.

Silicone chemistry began as a laboratory curiosity in 1846 when a scientific journal carried the report of the successful attempt to displace the four chlorines in silicon tetrachloride with organic radicals. It was done by adding silicon tetrachloride dropwise to anhydrous ethyl alcohol, cooled in a freezing mixture. The resulting compound, ethyl orthosilicate, reacted with water vapor to form silica gel, which varied in viscosity and other properties with the amount of water which was added.

Years later orthosilicates formed in this way were used in the manufacture of a paint, which upon hydrolysis would leave a hard coating of silica, or sand. A pioneer product in commercial silicones, the paint appeared in 1934.

In most cases organic groups will not combine directly with silicon. For sixty years, from the middle of the nineteenth century to the beginning of the twentieth, silicone chemists sought a desirable way to make this transfer. Organo metallic compounds such as those of zinc and mercury were used first. In 1885, it was found that sodium metal in a mixture of silicon chloride and certain organic chlorides would attach the organic groups to the silicon more simply and easily.

The question finally received a satisfactory answer in 1904 when Prof. F. S. Kipping, of Nottingham University, England, discovered that the organic compounds of magnesium, called Grignard reagents, offered a convenient, easily controlled method.

Industrial research laboratories entered the heretofore "academic" field of silicone chemistry about ten years ago. From the troublesome "glue-like" polymers discovered by Prof. Kipping, they developed insulating resins which would allow electrical equipment to operate at temperatures never dreamed of with the old type of insulation. Six patents on such resins are held by the General Electric Company.

Merely exposing the surface of cotton, paper or glass to the vapor of methyl chlorosilanes was found to

leave a water-repellent film which withstands washing, dry cleaning and even considerable abrasion. Treating the ceramic insulators in aircraft radios has been one of its many uses.

Dow Corning Corporation has developed silicone oils which stay fluid at the temperature of dry ice and are still usable at temperatures up to 400-500 degrees above zero Fahrenheit. Their fluids come in twelve different viscosity grades, ranging from one for use in bearings that must function at temperatures as low as 70 degrees below, to another for use at 500 degrees above. Their stability is much higher than that of petroleum oils of the same viscosity. They do not corrode metals or swell natural or synthetic rubber. They are resistant to oxidizing solutions, mineral acids, salts and alkalies.

Compass liquids, hydraulic fluids that act as damping fluids to prevent vibration of indicators or pointers on instruments, and surface treatment of ceramics to reduce surface conductivity are some of the uses for

liquid silicones. The water-white liquids were first limited to secret war uses but recent expansion in production makes them available for any war use indicated by their unusual combination of properties.

One of the important consequences of silicone chemistry will be the building of lighter and better electrical equipment, not only for the war effort, but for the home and the factory postwar. Engineers of Westinghouse Electric & Manufacturing Co. have reported unusual success in the use of silicone insulating materials. Greatly increased life, as well as reduction in the size and weight of electrical equipment, can be obtained through use of the new insulations, and machines can be operated in hot places where they would otherwise fail.

According to directors of industrial research laboratories working on silicones, practical applications of this new field of chemistry have just begun to be made. More surprising developments are ready to be announced soon.

Millionth Ton of Bombs

General Henry H. Arnold, Commanding General of the Army Air Forces, has revealed that on September 28, the AAF hit the enemy with its millionth ton of bombs in this war.

The AAF Commanding General disclosed that the bombs composing the millionth ton struck the Am-

moniak Oil Refinery at Merseberg-Leuna, close to the geographic center of Germany. This synthetic oil plant once had a capacity equal to about ten per cent of the total synthetic production available to Germany and was the third largest of her plants of this type.

—Official War Department Announcement

Vitamins In Your Food

by JANE STAFFORD

• MOST OF YOU probably know that liver rates high as a nourishing food and is rich in vitamins. Other variety meats may also be important sources of vitamins, it appears from a report by Dr. J. M. McIntire, Dr. B. S. Schweigert, Dr. E. J. Herbst and Prof. C. A. Elvehjem, of the University of Wisconsin, to the Journal of Nutrition. They tested the following meats: Canadian bacon, bologna, frankfurters, summer sausage, liver sausage, salami, pork links, tripe, sandwich meat, baby beef liver, beef liver, lamb heart, beef heart, corned beef, baby beef tongue and veal heart. In the case of the fresh meats, such as liver and heart, various cooking methods were also studied to see what effect they might have on vitamin content of the meat as finally eaten.

Canadian bacon, summer sausage, and sandwich meat, they report, contain larger amounts of thiamin (vitamin B₁) than fresh beef, veal or lamb, but smaller amounts than fresh pork. Corned beef was the poorest source of thiamin. Of the fresh organ meats studied, heart was richest in thiamin. Liver and tongue contained about the same amount as muscle meat.

Liver sausage contains nearly three or four times as much riboflavin, another of the B vitamins, as any of the other prepared meats. This is due

to its high liver content. The other prepared meats have about the same amount of riboflavin as fresh muscle meats. Corned beef contains the least. Among organ meats, liver was the best source of riboflavin. Heart is also a good source.

The prepared meats contain about the same amount of niacin, pellagra-preventing B vitamin, as fresh muscle meats. Liver was richer than any of the organ meats in this vitamin.

More of the vitamins are retained in the meats when broiled than when braised. The vitamin loss with boiling depends on the cooking time.

Vitamins from Beverages

The list of beverages that contribute vitamins to the daily diet is growing. You know, of course, about the vitamin C you get when you drink a glass of orange, grapefruit or tomato juice. This is the vitamin that protects you against scurvy. You can get it from foods as well as beverages. Potatoes, cabbage, melons and strawberries are examples of a fairly long list of foods supplying this vitamin.

Milk is another beverage that adds vitamins to your diet. The irradiated kind furnishes some vitamin D, but even without irradiation, milk makes an important vitamin contribution through its rich supply of riboflavin.

Unpleasant cracks at the corners of

the mouth, a condition known in folklore as "poor folks' mouth," and changes in the blood vessels of the eye which may impair vision result from lack of riboflavin. This vitamin, too, can be obtained from food as well as beverages. Cheese, eggs, lean meat, kidney, liver, kale and spinach are good sources.

Coffee, tea, beer, ale and meat extracts are the latest beverages added to the list of those supplying vitamins. Riboflavin and niacin, the pellagra-preventing vitamin, are the ones they contribute. The amounts furnished by tea and coffee are not very large, to be sure. You would have to drink 200 cups of tea to get your daily requirement of the riboflavin from this source alone, and 100 cups of coffee to meet the day's need for niacin.

Beer furnishes these two vitamins in more generous amounts. A little over a pint would furnish almost half the daily niacin requirement and 15% to 30% of the riboflavin requirement.

Meat extracts are not so commonly used for beverages here as in England, where their vitamin content was tested. A cup of them provides on the average one-tenth of the day's needs for riboflavin and seven of the 10 milligrams of niacin generally recommended for the daily ration.

Nutrition Rating for Chicken

Chicken has so often been advised in diets for invalids that it seems to have acquired the reputation of being light fare or invalid food in contrast to roasts and steaks. Actually, chicken

and other poultry rate as highly as other meats in protein, which is the most important value of meat in the diet.

"Pound for pound, poultry meat has the same quantity of protein as other meat," nutritionists of the U.S. Department of Agriculture state.

They point out that chicken has one advantage over other meats. This is the fact that it is usually served as a whole, rather than in separate cuts, and the giblets with their extra nourishing value are served either in the gravy or in stew or fricassee. This, the nutritionists state, gives the family opportunity for more all-around food value than they have from any single common cut of beef, lamb or pork.

Chicken giblets are especially rich in iron and in vitamin A. This is true also of the organs of other meat. Except for the giblets, however, poultry meat does not contain as much iron as the so-called red meats.

So far as the B vitamins are concerned, chicken and other meats are about the same with one exception. This exception is in content of vitamin B₁, or thiamin. Here chicken rates with beef but below lamb and veal and considerably below pork.

The dark meat of the chicken contains considerably more of one B vitamin, riboflavin, and probably more iron than the white meat. Since it also contains more of the flavoring substances, those who choose dark instead of white meat from chicken get the double benefit of more food value as well as more flavor.

Chem Quiz

Number Please!

Here is a chemistry quiz that will test your knowledge of the elements.

Here is the idea: If Ali Baba asked you for a metal whose atomic number is the same as the number of his band of famous thieves, what element would you give him?

Answer: Zirconium, number 40.

Phrases:

1. ____ nights in a barroom.
2. Behind the ____ ball.
3. The ____ dollar question.
4. Heinz ____ varieties.
5. ____ Up.
6. ____ Mule Team Borax.
7. Around the World in ____ Days.
8. ____ and Twenty Blackbirds.
9. Seven come ____.
10. ____ (Title of a book by Booth Tarkington.)
11. The ____ states.
12. The spirit of ____.
13. The Gay ____'s.
14. V-____ Program.
15. Tea for ____.
16. Friday the ____ th.
17. Stitch in time saves ____.
18. ____ strikes and you're out.
19. ____ men on a dead man's chest.
20. Mr. ____ by ____.

Below are some familiar number phrases with number left blank. Fill in the blanks with the atomic number of the element which is the correct answer. We give you some clues, in mixed-up order, which will make it so easy we have to slap on a time limit of 20 minutes. Ready - - - go!

Clues:

- (a) Magnesium
- (b) Lithium
- (c) Boron
- (d) Phosphorus
- (e) Chlorine
- (f) Mercury
- (g) Helium
- (h) Calcium
- (i) Fluorine
- (j) Nitrogen
- (k) Neon
- (l) Lanthanum
- (m) Beryllium
- (n) Cadmium
- (o) Oxygen
- (p) Osmium
- (q) Thorium
- (r) Gadolinium
- (s) Sodium
- (t) Aluminum

For clues in their correct order, turn to page 46.

Give yourself five points for each correct answer.

85 to 100 means you're practically an expert at the periodic table.

70 to 85 means you're average.

Below 70 is an invitation to take a long look at the periodic table tonight, and see for yourself how much chemistry it explains and clarifies for you.

Classics of Chemistry—
The Story of How the
Group O Elements Were Found

The Discovery of the Rare Gases

- NO ONE can tell with more authority the facts about how the elements were discovered than the scientists who made the discoveries or did early work upon them.

In the case of that rather young (from discovery standpoint) group of gases, the rare gases, that are listed in the periodic table as Group O, their autobiographies are quite accessible, although seldom seen in chemistry books.

There are brought together here the stories of the discoveries of helium, summarized by a great American authority, neon, argon,

krypton, and xenon, told by Ramsay, and radon, alias niton, alias emanation, described by Soddy.

There is a feeling of the eye-witness in these classics. These are the words of those who were there when it happened. They are front-line dispatches.

And there is another great virtue in the classics of science. The pioneers had to write simply because they were telling about things that even the experts did not know about. So these classics are good reading, now as when they were written.

The History of Helium

HELIUM: ITS HISTORY, PROPERTIES, AND COMMERCIAL DEVELOPMENT. By Richard B. Moore, in *Journal of the Franklin Institute*, Philadelphia, Pa., Vol. 191, No. 2, Feb. 1921.

- THE STORY OF HELIUM is one of the romances of science. There is probably nothing, unless it be the story of radium, which can compete with it in human interest. It represents one of the very best examples of a discovery in pure science which ultimately has a great commercial application.

In 1868 there was an eclipse of the sun which was visible in India. A number of scientific men were in India at the time making observations of the eclipse, and a spectroscope was for the first time turned on the solar chromosphere, that por-

tion of the atmosphere of the sun, about ten miles deep, which merges into the corona. A bright yellow line was observed which was at first thought to be the sodium line. Janssen, however, showed that this line was not exactly the same as the D_1 and D_2 lines of sodium, although extremely close to these lines. He, therefore, suggested that the line have the designation D_3 . Frankland and Lockyer decided that this line was due to a new element in the sun which had not previously been discovered on the earth and they suggested the name "Helium," from the

Greek word "Helios," meaning the sun.

For a great many years nothing more was done in connection with this element. In 1888, Dr. W. F. Hillebrand, of the United States Geological Survey, examined the gases which were evolved from certain uraninites when boiled with dilute sulphuric acid. Hillebrand obtained an inert gas which showed all of the properties of nitrogen. When sparked with hydrogen, in presence of hydrochloric acid, it gave ammonium chloride, and when sparked with oxygen, it gave oxides of nitrogen. The spectrum also was that of nitrogen. On the other hand, it was noticed that there were some lines in this spectrum which did not belong to nitrogen, and, in addition, after continuous sparking for a considerable period, there was a residue which diminished in volume very slowly. It is a great pity that American science was not responsible for the discovery of terrestrial helium. On the other hand, those who have worked with the rare gases can fully appreciate the difficulties attendant on work of this kind before the necessary technic was even partially developed.

In 1894, Sir William Ramsay, in conjunction with Lord Rayleigh, made his memorable discovery of argon in the atmosphere, which discovery was announced at the British Association Meeting in the same year. After this discovery, Ramsay looked for other sources of the element. He heard through Sir Henry Miers of the observation of Doctor Hillebrand, described above, and suspected that the inert gas found

by Hillebrand might be argon. He obtained a sample of the mineral clevite from Doctor Hillebrand, placed it in a tube connected with a Töpler pump, heated the mineral with sulphuric acid, pumped off the evolved gas, sparked the latter with oxygen, removed the excess of oxygen, and finally ran the purified gas into a spectrum tube. The spectrum was entirely different from that of argon, having as a chief characteristic a bright yellow line. Sir William once described to the writer, in his characteristic manner, his surprise at what he saw when he put his small spectroscope to his eye. He was expecting to see the argon spectrum, consisting of lines more or less evenly distributed across the whole field of the instrument, or at least the bands of nitrogen. Instead, he observed a very brilliant yellow line, with two or three fainter reds, as many greens, and as many violets. These were more or less masked by slight impurities in the gas. His surprise was so great that he thought at first there was something wrong with his spectroscope, and took out his handkerchief and mechanically wiped the prism. Others were called in who suggested various explanations for the bright yellow line, the most common being that it was the sodium line due to dirty electrodes or other causes. It was only when the spectrum of the sodium flame was compared with the yellow line from the spectrum tube that it became evident, and beyond question, that a new element — terrestrial helium — had been discovered. The wavelength was measured by Sir William Crookes and proved to coincide with

that of the D_3 solar line.

As would be natural under such circumstances, it was not long before the work had its critics, and the elemental character of the gas was attacked. Runge and Paschen showed that if the gas was allowed to pass through a porous plug, and from there into an evacuated spectrum tube, the light at first obtained was greenish, afterwards gradually becoming yellow. At the same time, the intensity of the D_3 line increased. From this they thought that two gases were probably present, and by means of diffusion they had made at least a partial separation. This claim received some support from the fact that the density of helium obtained from minerals was not always constant, and varied within moderate limits. If helium from this source was allowed to diffuse through porous earthenware, fractions of different densities could be obtained.

Travers proved that the difference of color in the spectrum was due to the difference in pressure in the tube. At extremely low pressures, the light given out was greenish in color, but as the pressure increased, the color became yellow and even orange yellow. In addition, Ramsay and Travers showed that by fractional diffusion helium from minerals could be separated into fractions of different density, but that these differences were due to traces of argon, which gas also was obtained from the minerals, in small quantity, mixed with the helium.

The presence of helium in the atmosphere was first discovered by Kayser in 1895, and was confirmed by Friedlander. Later the gas was

shown to be a constituent of the gases evolved from numerous mineral springs and was also found in volcanic gases, and ultimately in certain natural gases, particularly in the United States.

The discovery of argon, followed by the discovery of helium, was the forerunner of the series of brilliant researches by Ramsay and Travers, which gave to the world five new elements, commonly called rare gases of the atmosphere, namely, helium, neon, argon, krypton, and xenon.

Helium, as already stated, is found in the atmosphere. Ramsay's first determination of the proportion was one part in 245,000 by volume. Watson, using rather better methods, found what is probably a more accurate figure, namely, one volume in 185,000.

Samples so far at an altitude of several miles have been collected and analyzed for rare gases, and the percentage of helium found has always been approximately the normal one. J. H. Jeans has done some theorizing on the proportion of helium in the atmosphere at different altitudes. His theory is that the atmosphere consists of more or less concentric layers containing different proportions of constituents. The proportion of helium does not vary materially unless a considerable altitude is attained, such as fifty miles, at which point the air consists mainly of nitrogen and hydrogen, with three times as much helium as oxygen. At 100 miles the atmosphere is principally hydrogen and helium, and at 500 miles it consists entirely of hydrogen and helium. On this theory, a calculation of the

total mass of helium in the atmosphere gives eleven billion tons.

Others do not agree with this theory. Dr. Johnstone Stoney claims that the helium cannot be retained permanently by a planet of the size of our earth as the gas must be continually thrown off into space. The presence of helium in the atmosphere in constant proportions, therefore, depends upon a steady source of supply

to make up the loss. Stoney's conclusion is supported by both Ramsay and Moureu.

Helium is found in very minute quantities in sea and river water, and in a large number of the older rocks and minerals. It undoubtedly exists in some of the fixed stars as well as in the sun, and its presence has been spectroscopically determined in many nebulae.

Rare Gases of

THE RECENTLY DISCOVERED GASES AND THEIR RELATION TO THE PERIODIC LAW. By William Ramsay. An address delivered before the Deutschen chemischen Gesellschaft, December 19, 1898. Translated by "J. L. H." Printed in *Science*, February 24, 1899.

GENTLEMEN: It is well known to you all how the remarkable observation of Lord Rayleigh that nitrogen from the atmosphere possesses a greater density than that prepared from ammonia or nitrates led to the discovery of argon, a new constituent of the air. I need not say that had it not been for this observation the investigations of which I shall speak this evening would never have been carried out, at least not by me. You also, doubtless, will remember that the search for some compound of argon was rewarded, not by the attainment of the quest, but by the discovery, in cleveite and other rare uranium minerals, of helium, an element whose existence in the chromosphere of the sun had already been suspected. And, further, I hardly need recall to your minds that the density of helium is in round numbers 2, and that of argon 20, and that

the Atmosphere

the ratio of specific heats of both these gases, unlike that of most others, is 1.66.

From these figures it follows that the atomic weight of helium is 4 and that of argon 40. It is true that in many quarters this conclusion is not admitted, but I have always thought it better to recognize the validity of the theory of gases and accept the logical deductions than to deny the truth of the present theories. The only reason for not admitting the correctness of these atomic weights is that that of argon is greater than that of potassium, but this is no severer attack upon the validity of the periodic law than the accepted position of iodin after, instead of before, tellurium. As a matter of fact, all the more recent determinations of the atomic weight of tellurium give the figure 127.6, while that of iodin remains unchanged at 127.

Since these new elements form no compounds, it is not possible to decide the question by purely chemical methods. Were it only possible for us to prepare a single volatile compound of helium or of argon our problem would be solved. In spite of many attempts, I have not

been able to confirm Berthelot's results with benzine or carbon bisulfid. I have, however, offered to place a liter of argon at the disposal of my distinguished colleague, that he may repeat his experiments on a larger scale. No one can doubt that it is exceedingly desirable that the question of these atomic weights should be finally decided, and that by chemical methods.

In order that the subject may not depend wholly on physical theories, I have considered it from another standpoint. If we assume, as from countless chemical facts we are fully justified in doing, that the periodic law is true, then, giving helium the atomic weight 2 and argon 20, there is no possible place for an element of their mean atomic weight; for, unless we absolutely overturn the accepted views, there is no vacancy in the table for such an element. This appears from the following portion of the table:

H = 1	He = 2(?)	Li = 7	
Gl = 9.2	B = 11	C = 12	N = 14
O = 16	F = 19	A = 20(?)	

It is true there is space enough between He = 2 and Li = 7, but it is highly improbable that an element belonging to the argon series could have so low an atomic weight. The difference between adjacent members of the same group of elements is generally from 16 to 18 units, but here such a difference is wholly excluded. If, on the other hand, we assume He = 4 and A = 40, it would be, in my opinion, by no means improbable that such an element could exist whose atomic weight would be somewhere about 16 units greater than that of helium, and consequent-

ly 20 units less than that of argon. The discovery of such an element would be, therefore, not only a proof of the correctness of 40 as the atomic weight of argon, but also a confirmation of the present views regarding the significance of the specific heats of gases for their molecular weight.

A glance at the periodic table will make these considerations clear, for in the latter case we have the following series:

He = 4, Li = 7, Gl = 9.2, B = 11, C = 12, N = 14, O = 16, F = 19, (?) = 20, Na = 23, Mg = 24.3, Al = 27, Si = 28, P = 31, S = 32, Cl = 35.5, A = 40.

Shortly after the discovery of helium I began the search for this suspected element of atomic weight of about 20, at first in connection with Doctor Collie, my former assistant, and later with my present assistant, Dr. Travers. . . . [A large number of experiments were performed trying to extract gases from minerals, with no result.—ED.]

Our patience was now well-nigh exhausted. There seemed, however, to be a single ray of hope left, in an observation which had been made by Dr. Collie and myself. You will recall that the atomic weight of argon was apparently too high; at all events it would be more in harmony with the periodic law if the density of argon were 19 instead of 20, and hence its atomic weight 38 instead of 40. Hence, after some fruitless attempts to separate argon into more than one constituent by means of solution in water, we undertook a systematic diffusion of argon. We did not, however, carry this proced-

ure very far, for, at that time, we believed that helium was a more probable source of the desired gas; nevertheless, we found a slight difference in density between the gas which diffused first and that which remained undiffused. We, therefore, decided to prepare a large quantity of argon, and, after liquefying it, to investigate carefully the different fractions on distillation.

Such an operation demands much time. In the first place, the necessary apparatus is not to be found in any ordinary chemical laboratory; the preparation can not be carried out in glass tubes in an ordinary furnace, but requires iron tubes of large size and an especial furnace; in the second place, the operation must be repeated several times, for it is not convenient to work with an excessively large quantity of magnesium. As before, we removed the oxygen from the air by means of copper at a red heat; the atmospheric nitrogen remaining was collected in a large gasometer holding about 200 liters; after drying over concentrated sulphuric acid and phosphorous pentoxide, the gas was passed through an iron tube of 5 centimeters diameter filled with magnesium filings; the gas was then passed through a second copper oxid tube to remove the hydrogen; it then entered a galvanized iron gasometer, which was constructed like an ordinary illuminating gas gasometer, in order that the argon should come in contact with as little water as possible, since argon is quite appreciably soluble in water, and, had the ordinary form of gasometer been used, much would have been lost in this way. Again,

the gas had to be led over hot magnesium to reduce still further the quantity of nitrogen; and, at last, it was circulated between the gasometers, passing on its way through a mixture of thoroughly heated lime and magnesia at a red heat. This is a means of absorption, recommended by Maquenne, to remove the last of nitrogen. Since, however, it is not possible to dry the lime absolutely, hydrogen is taken up by the gas, and this must again be removed by copper oxid, in order that all the hydrogen may be burned, after which the water must again be removed by drying tubes.

These operations required several months and were chiefly directed by Dr. Travers . . .

[*After proving that the gases under investigation formed no compounds with any of the chemicals used in this purification process, the most hopeful line of investigation seemed to be refrigeration of the argon residue with liquid air.—ED.*]

Dr. Hampson, the inventor of a very simple and practical machine for the preparation of liquid air, which is based upon the same principle as that of Herr Linde, was so kind as to place large quantities of liquid air at my disposal. In order to become acquainted with the art of working with so unusual a material, I asked Dr. Hampson for a liter; with this Dr. Travers and I practiced and made different little experiments to prepare ourselves for the great experiment of liquefying argon.

It seemed to me a pity to boil away all the air without collecting the last

residue; for, though it seemed improbable that the looked-for element could be here, yet it was, indeed, possible that a heavier gas might accompany the argon. This suspicion was confirmed. The residue from the liquid air consisted chiefly of oxygen and argon, and, after removing the oxygen and nitrogen, beside the spectrum of argon were two brilliant lines, one in the yellow, which was not identical with D_3 of helium, and one in the green. This gas was decidedly heavier than argon; its density was 22.5 instead of the 20 of argon. We had, therefore, discovered a new body, which was an element, for the ratio between the specific heats was 1.66. To this element we gave the name "krypton." Up to this time we have not followed further the study of this element; we have, however, collected and preserved many residues which are rich in krypton. It was, however, our first intention to examine the lightest part of the argon. In many, however, we remarked, in passing, that the wavelength of the green line of krypton is exceedingly close to that of the northern lights, being 5,570, while the latter is 5,571.

Our whole supply of argon was now liquefied in the following manner: The gasometer containing the argon was connected with a series of tubes in which the gas passed over respectively hot copper oxid, concentrated sulphuric acid, and phosphorous pentoxid; it then passed by a two-way cock into a small flask, holding about 30 cubic centimeters, which was enclosed in a Dewar tube. By means of the other opening of the cock, the flask was connected

with a mercury gasometer. By means of a U-shaped capillary and mercury trough, it was also possible, through a three-way cock, to collect the gas at will in glass tubes. About 50 cubic centimeters of liquid air were poured into the double walled tube, and, by means of a Fleuss air pump kept constantly in action, the liquid air boiled at 10 to 15 millimeters pressure. The argon liquefied rapidly as soon as subjected to this low temperature, and in the course of half an hour it was completely condensed. Altogether there were about 25 cubic centimeters of a clear, limpid, colorless liquid, in which floated white flakes of a solid substance. By stopping the pump the pressure over the liquid air was now increased, and the argon boiled quietly, the first portions of the gas being collected in the mercury gasometer. Changing now the three-way cock, the largest portion of the argon passed back into the iron gasometer; after nearly all the liquid had boiled away and only the solid substance was left in the flask, the last portions of the gas were collected separately. The solid substance remained persistently in the flask; it was slowly volatilized by means of a Töpler pump, which stood in connection with the apparatus.

We first directed our attention to the lighter fractions, for these had for us the greatest interest. The density of this gas was found to be 14.67; the ratio between the specific heats was as usual 1.66, and the spectrum showed, beside the well-known groupings of argon, a large number of red, orange, and yellow lines of varying intensity. Evidently we had

before us a new element, which was contaminated with argon.

This gas was then liquefied in a similar apparatus to that first used, but constructed on a smaller scale; a portion, however, remained uncondensed. Even by raising the reservoir of the mercury gasometer until an overpressure of an atmosphere was reached, it was impossible to convert all the gas into a liquid, although the temperature of the boiling air was reduced as low as possible by rapid pumping. By repeated raising and lowering of the reservoir we finally passed all the gas through the cooled space, in order to free it, as far as possible, from argon. The uncondensable gas was collected by itself, and the remainder was evaporated into another gasometer.

You can well imagine how eager we were to know what the density of this purified gas would prove to be. It was immediately weighed. Our satisfaction can well be realized when we found that its density was 9.76. Since, however, its spectrum at low pressure still showed argon lines, though weak, we were compelled to admit that this number was certainly too high. It was impossible that this gas should not contain argon, since at the temperature used argon possessed a measurable vapor pressure.

We have, therefore, estimated that the density of the pure gas is 9.65. Here our work for the time was ended by the beginning of the summer holidays.

On our return we resumed the study of this gas, which we will hereafter designate by its name of "neon." Its spectrum was photographed by Mr. Baly, one of my assistants, by

means of a spectrometer which we had constructed during the vacation. To our astonishment, the lines of helium were easily recognized. A comparison photograph showed this beyond all question. Hence the density of the gas was in all probability too low, owing to the presence of the helium. Since now the temperature used was insufficient to liquefy the neon, and since the argon had been removed as far as possible, we had to face the problem of how one could free neon from its accompanying impurities. A means was found in its solubility. It is well known that the solubility of those gases which do not react chemically with the solvent follows in general the same order as their condensability. According to this helium should have a lesser solubility than neon, and neon than argon. The solubility of these gases in water is, however, too slight to be available for their separation. We have, therefore, used liquid oxygen as a solvent. This mixes with all three gases and boils at a temperature not far from the boiling point of argon. We therefore mixed the gas with sufficient oxygen to be almost wholly condensed at the temperature attained by boiling air at the lowest possible pressure. The uncondensed portion, about one-fifth of the whole, was separated and collected as that richest in helium; the middle portion we considered as purified neon, while the remainder consisted of a mixture of argon and neon; naturally, all these portions contained oxygen in larger or smaller quantities.

After the removal of the oxygen, which was accomplished by passage

over hot copper filings, we determined the density and refractivity of the middle portion. The density in two determinations was 10.04 and 10.19; the second figure was obtained after passing the electric spark through the gas mixed with oxygen in the presence of caustic potash and subsequent removal of the oxygen by phosphorus. The entire quantity weighed was only 30 cubic centimeters at a pressure of 250 millimeters. The weight was 0.0095 gram. I mention these figures in order to show with what an exceedingly small quantity of gas it is possible to carry out a very satisfactory density determination.

The refractivity of this portion with reference to the air as unity was 0.338. This portion still showed the spectra of argon and helium, and was, therefore, submitted to a second purification, in which the heavier part was more completely removed than the lighter. Even this purification, however, did not remove all the argon, but its quantity was decidedly diminished. The density was somewhat diminished, and helium was stronger in the spectrum. The entire amount of neon had become, by these operations, so divided up that it was not possible to carry out a further purification without preparing a greater quantity of crude neon. On this Dr. Travers and I are at present engaged.

In the meantime Mr. Baly has made exact measurements of the lines of the neon spectrum, at the same time eliminating all the lines which belong to argon and to helium by superposed plates. The values were compared with iron lines photo-

graphed upon the same plate, and the measurements were carried out by means of different pairs of these known lines. . . .

Up to the present we have had little time to study thoroughly the other companion of argon in the atmosphere. Dr. Travers and I have, however, worked upon it. The heavier fraction of the air contains three gases, one of which appears very perplexing. We have named it "metargon." This gas remains, mixed with excess of argon, after the evaporation of liquid air or argon. Up to this time we have not succeeded in obtaining it in a condition free from argon. Its peculiarity is that when it is mixed with oxygen and subjected to the influence of the electric spark in presence of caustic potash it shows constantly the "Swan-spectrum" as of carbon monoxid. We have treated a mixture of carbon monoxid and argon in a similar way, and, after fifteen minutes sparking, all the carbon had disappeared; in a Plücker tube no trace of the carbon spectrum could be recognized. I will, however, not yet venture to express an opinion as to the nature of this gas. It needs further investigation, and for this at present we have no time.

As regards krypton, which is distinguished by three brilliant lines, one in red, one in yellow and one in green, we are in much the same position. We have collected a considerable quantity of the impure gas, which shows the spectrum finely, although that of argon is also present. We hope that we shall soon be able to pursue this portion of our work further. We can merely note

here that the specific gravity of the gas which shows this spectrum in such a marked way is not far different from that of argon.

The heaviest of these gases we have weighed, although in impure condition. Its density is 32.5. I need not call your attention to the fact that there is space for an element of the helium group between bromine and rubidium. Such an element should have an atomic weight of 81 to 83, which corresponds to a density of 40.5 to 41.5, under the very probable supposition that, like the other gases of this group, it is monatomic. The spectrum of this gas, which we have

named "xenon"—the stranger—has many lines; none of these are of marked intensity, and in this respect the spectrum resembles somewhat that of argon. It is also analogous to argon in another particular, that the spectrum undergoes a remarkable change when a Leyden jar is put into the circuit. As with argon, many new blue and green lines appear, while other lines, mostly in the red, either disappear or lose much of their intensity. Further than this we have not proceeded in studying xenon; for our attention has been given chiefly to neon, as well as to a problem regarding argon.

The Investigation of Radon

THE INTERPRETATION OF RADIUM AND THE STRUCTURE OF THE ATOM. By Frederick Soddy. G. P. Putnam's Sons, New York, 1922.

If this specimen of radium bromide was dissolved in water and the liquid evaporated down to dryness in order to get back the solid compound, it would be found that as the result of this very simple operation the radium had lost the greater part of its radioactivity in the process. The penetrating β - and γ -rays would have completely disappeared, and the non-penetrating X-rays would only be one quarter as powerful as initially. Then a strange thing would happen. Left to itself the radium would spontaneously recover its lost activity, little by little from day to day, and at the end of a month it would not be appreciably less active than it at first was, or as it now is.

This appears to be in direct conflict with the statement previously made that the radioactivity of radium cannot be affected by any known process, but it is only apparently so. If we study the process carefully we shall find that when the radium is dissolved in water "something" escapes into the air, and this "something" is intensely radioactive. It diffuses about in the air, but remains contained within a closed vessel, if it is gas-tight. In short, this "something" is a new gas possessing the property of radio-activity to a very intense degree.

We owe the greater part of our knowledge of this new radioactive gas to Sir Ernest Rutherford, who has given to it a special name. He called it the *emanation of radium*, or, for short, simply *the emanation*. The vague term "emanation" is, with our present exact knowledge of its

real nature, apt to mislead. Some, unfortunately, have used the term "emanation" or "emanations" in speaking of the various *radiations* which radium emits, and which we have already considered in some detail. Sir William Ramsay has proposed the name "Niton" for this new gas, in order to emphasize its relationship to the other argon gases. However, as similar new gases or emanations are given by two other of the radioactive elements, thorium and actinium, the original term has been generally retained. The term "emanation," qualified when necessary by the name of the radioactive element producing it, denotes one of these new gaseous bodies, and it is necessary not to confuse this particular use with its older and more general uses. . . .

It has even been found possible to settle the chemical nature of this new gas, and to place it in its proper family of elements in the periodic table. Almost all gases, according to their various natures, are absorbed when subjected to the action of various chemical reagents. Thus oxygen is absorbed by phosphorus, hydrogen by heated copper oxide, nitrogen by heated magnesium, and so on. The exceptions, namely, gases which are not absorbed by any reagents and which will not combine with anything, are the newly discovered gases of Lord Rayleigh and Sir William Ramsay—argon, helium, neon, etc.—which exist in atmospheric air. The quantity in the air of these gases is extremely minute except in the single case of argon, which is present to the extent of one per cent. The radium emanation, like argon, is not

absorbed by any known reagent, and does not appear to possess any power of chemical combination. It may be passed unchanged through absorbents, or subjected to drastic chemical treatment which would suffice to absorb every known gas except those of the argon type, and the conclusion has been arrived at that the emanation is an element of the same family nature as the argon gases. Like them, it exists in the form of single atoms—that is, its molecule is monatomic. Radium, on the other hand, in its chemical nature is extremely similar to barium, strontium, and calcium, a family known as the alkaline-earth elements. None other of the argon elements or the alkaline-earth elements are radioactive, and yet the radioactive elements are quite normal in their chemical properties, closely resembling ordinary elements, and being associated in the clearest and closest way with one or another of the old well-known types or families. More recently, by using quantities of radium about fifteen times as great as those used tonight in our experiments, it has been possible to obtain enough of the emanation for it to be possible to photograph its spectrum. This proves to be a new and characteristic bright-line spectrum, resembling in general character the spectra of the other argon gases, but absolutely distinct.

It has been found possible to obtain some idea of the density of the emanation of radium, and therefore of the weight of its atom, from experiments on the rate of its diffusion from one place to another. These indicate that the gas is extremely dense—denser probably than mercury va-

pour—and therefore that it has a very heavy atom. Finally, by means of a new special micro-balance thousands of times more sensitive than the most delicately constructed chemist's balance, the emanation has actually been weighed by Sir William Ramsay and

Mr. Whytlaw-Gray. These experiments and the whole of the available evidence agree in indicating that the atomic weight of the emanation is 222, which is four units below that of radium, and therefore is the fourth heaviest known.

Who's Who Among The Rare Gases

SIR JOSEPH LOCKYER (1836-1920). Astronomy was first his hobby, then his vocation. Simultaneously with Janssen he discovered how to see solar prominences when there is no eclipse. A solar chemist, he spent many years identifying lines in sun's spectrum. In 1868 he found line D₃ characterizing an unknown element, which he named the element Helium for the sun, but did not expect to find it on earth. He lived long enough to see it not only discovered but in commercial use.

JOHN WILLIAM STRUTT, 3rd Baron Rayleigh (1842-1919) known as a mathematical physicist before he succeeded to the title. "Rayleigh" did not come from the rays he studied. He succeeded Clerk Maxwell as Cavendish Professor of Physics at Cambridge. Later at the Royal Institution, trying to determine the atomic weight of nitrogen more exactly, he and William Ramsay discovered argon. He received the Nobel Prize in 1904. Rayleigh was Chancellor of Cambridge University during the latter part of his life.

SIR WILLIAM RAMSAY (1852-1916) was Professor of Chemistry at University College, London, where he helped Lord Rayleigh separate argon

from nitrogen. Ramsay discovered helium in air and found other inert gases, neon, krypton, xenon. He proved that helium comes from disintegration of radioactive material. He received the Nobel Prize with Rayleigh in 1904.

WILLIAM FRANCIS HILLEBRAND (1853-1925) was born in Hawaii. He became Chief Chemist of the U. S. Bureau of Standards. While making meticulous atomic weight determinations, he saw the helium spectrum, just missed recognizing its presence for the first observation on earth of the sun element.

RICHARD BISHOP MOORE (1871-1931) developed large-scale production of helium from natural gas wells for the U. S. Government at the end of the first World War, making possible the use of non-inflammable gas for lighter-than-air airships.

FREDERICK SODDY (1877-) worked at McGill University, Montreal, Canada, with Sir Ernest Rutherford, New Zealand-born experimenter on radio-activity, and in London with Ramsay on gases. Soddy unraveled the mystery of isotopes and received the Nobel Prize in 1921. He is now connected with Oxford University, England.

The Anatomy of Explosions
Explained by An Expert

What Happens in A "Bang!"

Opening Paragraphs of a New Book on *Explosions, Their Anatomy and Destructiveness* (McGraw-Hill Book Co. \$1.50)

by CLARK SHOVE ROBINSON

• IN A GENERAL sort of way, an explosion consists of the very sudden production of large quantities of gases, usually hot, from a much smaller amount of a solid, a liquid, or a gas. This is usually accompanied by a loud noise or report.

Solid gunpowder explodes in a shotgun or rifle and pushes the shot or the bullet out through the barrel at high velocity. Liquid nitroglycerin explodes in the bottom of a dried-up oil well, cracking the surrounding rock and liberating more oil to flow into the well. Natural gas diluted with air explodes in the cylinder of a gas engine, pushing the piston through the cylinder and producing power from its movement. Sometimes mixtures explode. For example, solid charcoal mixed with liquid oxygen is placed in a hole drilled in the seam of a coal mine, and when it explodes the coal is cracked and broken so that it can be removed. Or a mixture of heavy oil and air explodes in the cylinder of a Diesel engine, producing its power. Then there is the case of the wheat-flour dust, suspended in the air of a grain elevator, which explodes when ignited, wrecking the elevator. In every one of these explosions, not only are large quantities of gases formed very

suddenly, but a great deal of heat is liberated as well, so that the explosion products are very hot. The very hot gases confined within the container that holds the original material are responsible for the pressure that bursts the container and produces the noise so characteristic of explosions. Once in a while, however, a steam boiler explodes or a cylinder of compressed CO₂ gas lets go. Although these are explosions in the strict sense of the word, they differ from the preceding examples by absorbing heat rather than by producing it, so that the explosion products are colder than the material from which they came. Like all other explosions mentioned, however, they are capable of doing great damage to the surroundings if uncontrolled.

There are several kinds of explosions, characterized by their intensity, expressed in brisance or shattering power, and involving the time during which the explosion is taking place. Nitroglycerin explodes so rapidly that, in a container a foot or so across, the entire explosion is over in about 1/25,000 of a second. This explosion is one of the most intense of its kind and its shattering power is tremendous. Anything in the immediate vicinity is broken into small frag-

ments before it has a chance to move. Nitroglycerin dynamite, which is made by soaking that liquid in a porous material like sawdust, is almost as brisant, and it is possible to explode some of it placed on top of a boulder and have it break up the boulder even though it is unconfined in any way. The boulder simply cannot get out of the way in time. An explosion that requires 1/10,000 of a second has much more shattering power than one that lasts 1/100 of a

second. Gunpowder produces one of the latter kind. When used as a propellant in a firearm, it must push, not shatter, so that the projectile will be moved without bursting the gun barrel. This same explosive, placed on the top of a boulder in the open and exploded, would have no effect on the boulder because the explosion would be slow enough for the forces to be dissipated into the air away from the rock. The most brisant explosives are the most destructive.

Young Chemists Have Chance to Win Scholarships

Fourth Search for Science Talent

• ALL OVER THE United States thousands of high school seniors, many interested in Chemistry, are eagerly entering the Fourth Annual Science Talent Search for \$11,000 in Westinghouse Science Scholarships.

The Annual Science Talent Search has been carried on jointly by Science Clubs of America, administered by Science Service with financial co-operation from Westinghouse Electric & Manufacturing Company for three years. Many of the boys and girls who will compete this year have been planning to do so since they were high school freshmen.

In notifying contestants that the essay topic for this year is "My Scientific Project," this advice was given them: "Do not be afraid to work in new fields or even on problems that some may consider uninviting. Be sure that what you do is really scientific in plan, method and experiment. Demonstrate, don't just think wishfully."

In addition to recording their findings in an essay of about 1,000 words on "My Scientific Project," each contestant will take a three-hour Science Aptitude Examination during December. This examination is especially compiled for the Fourth Annual Science Talent Search and is designed to discover science aptitude rather than test knowledge of science. Each contestant will also submit recommendations from principals and science teachers and personal data about their own extracurricular accomplishments.

It is expected that at least 15,000 seniors will enter this year's search which closes December 27.

From this number 300 will be picked for honorable mention and will be recommended to colleges, universities and technical schools as science students worthy of scholarship consideration.

From the 300 honorable mentions 40 contestants will be picked as trip winners and will be invited to Washington for a 5-day all-expense Science Talent Institute where they will meet prominent scientists and learn of the latest developments in science for the winning of the war and preparing for the peace.

The 40 winners who come to Washington will be personally interviewed by a judging committee to determine their eligibility for the Westinghouse Science Scholarships which total \$11,000. One boy and one girl will each receive \$2,400 Westinghouse Grand Science Scholarships (\$600 per year for four years). Eight other contestants will receive 4-year scholarships of \$400 each (\$100 per year for four years). Addi-

tional scholarships totaling \$3,000 will be awarded at the discretion of the judges who are Dr. Harlow Shapley, Director, Harvard College Observatory; Dr. Steuart Henderson Britt, Washington psychologist; and Dr. Harold A. Edgerton, Director, Occupational Opportunities Service, Ohio State University. The latter two are also the designers of the Science Aptitude Examination. Those unable to use their scholarships before entering war service will find them waiting for them when they return to civilian life.

Complete details of the Fourth Annual Science Talent Search can be obtained by writing to Science Clubs of America, 1719 N Street, N.W., Washington 6, D.C.

Lye Speeds Potato Peeling

• POTATOES can be peeled at the rate of more than 18,000 pounds per hour when lye is used to do the job, A. H. Copeland, Jr., R. M. Chatters and R. D. Kerwin, of the research laboratories of the Diamond Alkali Company at Painesville, Ohio, have reported.

The lye peeling method is now being widely used for other vegetables and fruit for the armed services. Besides the saving in labor, new medicinals, plastic ingredients and valuable oils have been discovered in peels and seeds hitherto wasted.

Answers to Chem Quiz on Page 31

1. Neon 10
2. Oxygen 8
3. Gadolinium 64
4. Lanthanum 57
5. Nitrogen 7
6. Calcium 20
7. Mercury 80
8. Beryllium 4
9. Sodium 11
10. Chlorine 17
11. Cadmium 48
12. Osmium 76
13. Thorium 90
14. Magnesium 12
15. Helium 2
16. Aluminum 13
17. Fluorine 9
18. Lithium 3
19. Phosphorus 15
20. Boron 5

Rubber and Plastic from Dichlorostyrene

• BOTH HEAT-RESISTANT plastic and synthetic rubber can now be made from a new chemical compound developed by the Mathieson Alkali Works. The new plastic is expected to be of particular importance in electronics and, in general, wherever electrical insulation at high temperatures is required. The rubber is under test in heavy duty tires on motor vehicles.

The new compound, from which both materials are made, is known

as dichlorostyrene. The rubber is made from it and butadiene.

Dichlorostyrene is a chlorinated product. Its monomers are highly active and polymerize readily. The polydichlorostyrene, the plastic, resembles polystyrene in chemical resistance, solubility and general appearance. It differs chiefly by its resistance to heat, and it is more resistant to water. It is stable and shows no tendency to lose hydrochloric acid. It may be molded by conventional methods.



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"Strictly on the q.t., I think I can put you in the way of some tetramethyldiaminobenzophenone."

Beginning a Series On
Fundamentals of Chemistry

An Introduction to Chemistry

by HELEN M. DAVIS

First of a series of articles to appear monthly that will take the reader along the pathways of basic chemistry, by easy stages.

• THE WORLD in which we live is made up of a bewildering variety of materials. For many thousands of years people have lived and died knowing almost nothing of the way these substances behave and how they have come to be.

Very gradually a body of useful facts has been gathered one at a time, recipes for making bronze or iron knives, for concocting medicines of real or imaginary efficacy, for making soaps and dyes, for tanning leather. These results were originally reached by trial and error. When the batch turned out well the early experimenter tried to do just the same things next time.

Science of Chemistry

Gradually innumerable little streams of specialized knowledge trickled together to form a considerable pool of useful information. When Lavoisier worked out the mechanism of oxidation in 1777, invented chemical nomenclature and systematized the conception of valence, chemistry became a science. When Mendeleeff in 1869 made the vastly illuminating generalization

If he succeeded, the whole rigamarole he had gone through, including the words he had said, became his private recipe. If he failed, he blamed it on the Devil. There must have been many failures, for the Devil became thoroughly identified with this magic sort of cookery, especially in the Middle Ages in Europe.

In palace, monastery and hovel a favorite amusement then was the search for the right recipe to turn base metals into gold. Brimstone flavored the fires of Hell because sulfide ores are the easiest to turn into metal. A magic book became the alchemist's monitor because what little was really known about materials had been preserved in Arabic during the blackout of civilization in Europe.

known as the "Periodic Table" which resolves the whole complex universe into a beautifully ordered pattern of variation, the science of chemistry came of age.

The close of the 19th century brought the disconcerting news of five new and unsuspected elements, and the astounding property of radioactivity with its strange fulfillment of the alchemist's dream. When

these developments were found to fit perfectly into the previously determined arrangement of the elements, it was obvious that the scheme

of relationships was based on something fundamental to the structure of matter.

The Elements

Matter, according to the lore the chemists have accumulated, consists of 93 elements in varying combinations with each other. Most of these elements are metals. Their properties are in general similar to the familiar seven first discovered by man in the dawn of history: gold, silver, mercury, copper, iron, tin and lead.

A world of romantic fancy is packed into the associations the ancients made up by coupling the metals with the planets and the Roman gods. Gold represented the sun, silver the moon. These metals were nobles in their own right. Copper, the beautiful metal, was associated with Venus, planet and goddess. Iron, metal of weapons, similarly associated with Mars, dates this traditional arrangement for us as after the close of the Bronze Age

of human culture. Mercury still retains the name of the swift-running god and the swift-moving planet for the only liquid metal, "quick-silver." Tin, the bright white metal, belonged to the planet Jupiter and was thought to share some of the god's effulgence, while Saturn, dark and sinister, claimed the dull planet and the non-lustrous lead. Things went in sevens for the ancients, because seven was a lucky number.

Modern chemists find that out of the 93 elements, only about 16 can definitely be said to have no metallic properties. Among these are the elements which make up our world of living things. Chemistry tells how these few materials combine to build the infinitely complex world revealed to us in varying aspects by our five senses.

The Five Senses

Each of our senses really reveals to the mind a very different world. Three of the senses are primarily physical. Touch enables us to measure objects with which we come in contact. Sight we correlate with touch so well that we can measure anything from which light can reach our eyes, even as far away as the farthest super-galaxy outside our universe. Sight responds to a kind of wave motion which can pass through empty space. Hearing responds to another kind of wave,

which travels through air.

Very little association exists in our minds between hearing and the other senses. This is the reason for one of the problems encountered by sound motion pictures and television. The only associations with music or other pure sound which are acceptable to our experience are pictures of the source of the sound—an instrument with its operator, or human being with open mouth—or pictures of a dance, a spectacle or a drama, whose suitability to the music

is a subject of hot debate by the music critics. Nevertheless, the scientist can, by electronic devices, interchange light and sound waves, and measure them with equal certainty.

In contrast to the three physical senses, taste and smell are chemical senses. Taste depends upon the solubility of the substance tasted, and completely insoluble substances cause no response on the tongue. Taste correlates with touch to give a feeling of texture, as smoothness, crispness or sharpness, and with sight to the extent that it is important for food to look attractive as well as to taste and smell good.

Smell is our most mysterious sense. Little is known accurately about its workings. It is correlated

so closely with taste that it is actually the chief component of flavor. True taste is believed to give rise to only four sensations: sweetness, sourness, bitterness and saltiness. As we learn when a cold robs us of the sense of smell, the world loses much of its interest with that often disregarded sensation.

The chemist uses all five of his senses to learn about the world. Sometimes taste and smell tell him more than the others do. But for accuracy of measurement he must depend on touch, hearing and sight. Instruments must be designed to present evidence to these senses in such a form that it can be compared with other evidence previously recorded. This usually means reading numbers on a graduated scale.

Looking for the Atom

Glass had been made for thousands of years before it was discovered that a clear, lens-shaped piece of it would enlarge vision. The telescope was invented first, and Galileo in 1609 brought the distant near. Leeuwenhoek's simple lenses in 1673 began to reveal the invisible world at our feet. Robert Hooke, first Secretary of London's Royal Society, in 1664 devised the compound microscope, one of the scientist's most indispensable tools.

Almost illimitable in breadth as is the world unlocked by the compound microscope, that instrument has a very definite limit of magnifying power, for it cannot resolve the image of an object smaller than one-half the wave-length of visible light. Light waves vary but slightly in

wave-length from one end of the visible spectrum to the other. Of the enormous band of radiations all around us, we are blind to all but a pitifully meager section. The microscope shows the chemist beautiful details of structure in his crystals, but offers no hint of the riddle he most wants to solve—what is the ultimate structure of the elements and how do their combinations take place?

When a scientist is balked by such a barrier to direct observation, he looks around for an indirect method of getting information. If possible, he uses several different methods, so that the agreements and contradictions in his results will limit his interpretation of the evidence. If he cannot learn what a thing is, some-

times he can learn what it is not. When he learns that the object he wants to see is too small ever to be seen by the eye by ordinary light, he

Beyond the Microscope

One indirect way of seeing is familiar when a shaft of sunlight lights up dust particles in the air. Zsigmondy, about 1903, applied this principle to a dark-field microscope and saw flashes of light reflected by invisible particles in an apparently clear solution. He called this arrangement the "ultra-microscope." With it the limit of vision is extended downward, and we can explore the realm of "Brownian movement," a mysterious sort of zig-zag motion constantly apparent in particles of matter in the colloidal range of sizes. But the chemist is not yet satisfied. These particles are thousands of times larger than the ultimate bits of matter his calculations tell him are involved in the formation of his compounds.

Having accomplished about all he can with visible light, the scientist tries other radiations whose wavelength is less. X-rays affect the photographic plate, so there is a chance that man may see a picture of what is too minute for his vision. Lenses of glass or quartz are too gross for his purpose, but the properties of the crystal itself can be made to show up its structure. Indeed it was upon the presumption that crystalline planes

reflects that the photographic plate can see some light invisible to the eye, and that there are indirect ways of seeing as well as direct ones.

Microscope

would act as diffraction gratings for X-rays that Laue in 1913 induced Friedrich and Knipping to take the photographs which showed up crystal lattice structure. W. H. Bragg shortly afterward interpreted the symmetrical patterns obtained from such photographs as due to the actual positions of the atoms themselves in the crystals, and chemists thus got a new line on how matter is put together.

With newer techniques of the physicist in handling streams of electrons, a still finer tool has been put to work on the search for the smallest entities of matter. Occasional charged particles can be made to record their own erratic paths. Electron streams can bombard various sorts of matter, and certain results can be recorded photographically. We are tantalizingly close to seeing the atom, but still it keeps just beyond our ken. The new electron microscope shows us much detail that we have only guessed at before. Perhaps some of the finest particles it shows are close in size to the very biggest molecules. At any time some new refinement of technique may bring us closer to the chemist's goal, a real glimpse at the smallest unit of an element that can exist as such.

Atoms and Molecules

It is at the level of the atom that chemists and physicists part company. The physicist says, "THE

ATOM," the chemist says, "Which atom?" He is more interested in how an atom of one element differs

from that of another than in what each is made of. He has a hard time to keep from thinking of them as solid balls. He lets the physicist look below their surfaces to see them as miniature solar systems or mathematical waves.

The physicist, to explain the attractions between the elements, has evolved an ingenious theory of shared electrons in the outer orbits of their atoms. The chemist thinks it sounds plausible, but he does not worry overmuch about the exact mechanism of attraction of elements for each other. He knows the attraction exists. He thinks of it more as a system of grappling hooks, or grasping hands. He has called the attraction "valence" since Goethe in 1809 took over his

earlier term "elective affinity" to be a synonym for "free love."

And here, perhaps, a word of caution should be inserted about personifying the chemical elements. It is a tempting figure of speech. Many of the analogies hold good. But it leads to awkward complications. One may set the stage for a chemical wedding, with the catalyst as a chemical parson, and find that the groom has turned up with three beautiful brides. Getting around that as best one can, and proceeding with subsequent adventures, one is next embarrassed to find that the hero has changed sex in the middle of the continuity. No. In the world of chemistry we are on a level far below the mechanisms of living matter. Chemicals obey their own laws.

Atoms in Combination

One of the earliest laws of chemistry to be worked out is that of combination in definite proportion. If a measured quantity of hydrogen is burned in an unlimited atmosphere of oxygen, it will combine with just so much oxygen and no more. If there is less than that amount of oxygen, some of the hydrogen will remain uncombined. The proportions are 8 of oxygen to 1 of hydrogen by weight. All chemical measurements are based on weight, i.e. mass. It is inconvenient to weigh a gas, but it can be done with perfect accuracy. The well-known formula H_2O is reached by comparing the combining weights of hydrogen and oxygen in various compounds. From these computations it is established that one unit of oxygen is 16 times as heavy as one unit of hydrogen, and therefore

the 8:1 ratio must mean two H units.

The law of definite proportions, worked out by Dalton in 1803, really settled the theory as to whether atoms exist. Since, to form water, two parts of hydrogen always combine with one of oxygen, if those parts are made smaller and smaller we must eventually reach two hydrogen atoms in combination with one oxygen atom. The stream of matter must be made up of discrete particles like grains of sand, not of particles of no definite size that coalesce like drops of water.

The chemist gazes, with his mind's eye, at his two H atoms combined with one O atom, and needs a name for the resulting unit of a compound, the smallest unit of water which can exist as such. He calls it a molecule. His studies of crystal lattices tell him that the word is an oversimplification.

tion. A single molecule as such may never exist in nature. When several atoms get together they probably start at once to build themselves into some kind of framework or con-

tinuum that makes them a gas, a liquid, a crystal or what not. This concerns the physicist. It concerns the chemist not at all. He needs the molecule, so for him it exists.

The Chemical Balance

Because weighing is one of the most important operations in chemistry, the chemist has evolved his own special scale, a balance nicely contrived to combine the mutually antagonistic conditions for sensitivity and accuracy. It is graduated in the metric system and designed to weigh positively one ten-thousandth of a gram (0.0001).

With his balance, the chemist has learned a great deal more about the elements than that they always combine in definite proportions. The next step was the law of multiple proportions. Some elements will combine with each other to form not one but a series of compounds. Nitrogen and oxygen combine to form six oxides of nitrogen. Yet in each of these compounds a definite weight of oxygen combines with one nitrogen atom, and the combining weights of oxygen in the five heavier oxides are simple multiples of that in the lightest one. Reduced to their lowest ratios the formulas of the six are: N_2O , NO , N_2O_3 , NO_2 , N_2O_5 and NO_3 . The probable formulas of the molecules are N_2O , N_2O_2 , N_2O_3 , N_2O_4 , N_2O_5 and N_2O_6 . From actual weights of these gases we learn that they must combine atom by atom, but that under some conditions two nitrogen atoms can hold one oxygen atom while under other conditions two oxygen atoms combine with one of nitrogen, and so on. This differ-

ence in combining power is valence. The chemist studies the conditions under which differences in valence appear, and so learns to make at will the whole series of possible combinations between any pairs or groups of elements. He is proud of being able to make combinations which he has never found under natural conditions.

The next step after combining hydrogen with oxygen and nitrogen with oxygen, obviously, is to see whether hydrogen will combine with nitrogen. It will, in the proportion NH_3 , to form ammonia gas, and all three elements will combine to form NH_4OH , ammonium hydroxide, commonly sold as a household cleaning aid. Its sharp, breath-taking odor is a familiar chemical experience.

The three elements also combine in different proportions, HNO_3 , to form nitric acid, a liquid with very different properties. They will combine in other ratios. By making an immense number of combinations of one element with another, it is possible to reduce the ratios of their combining weights to their least common denominators. This was done in the early part of the last century. At that time little was known about systematic arrangements of the elements, and an enormous amount of patient calculation had to be gone through before the list of atomic weights was complete.

Atomic Weight

An atomic weight is not to be read as pounds or grams. It represents the number of times heavier a unit quantity of that element is than the same quantity of hydrogen.

Hydrogen is the lightest element we know. We have reason to believe that it is the lightest possible element, that its atom is made up of one nucleus and one electron, the simplest possible arrangement of matter as we envision it. Nevertheless, if one of those upsetting new discoveries by which nature occasionally confounds our complacency should reveal still more minute complexities in the ultimate structure of matter, by giving us an indisputable element lighter than hydrogen, the theory of atomic weights would not be "overthrown." All the chemist would have to do to accommodate his list of atomic weights to the new fact would be to multiply each of them by a numerical factor based on the weight of the new element.

Nothing in nature is ever quite so definite and unequivocal that there is no mystery left in it. Since ratios of combining weights must

reflect ratios of the weights of atoms, and atoms are probably all composed of the same materials in different proportions, it is obvious that the weights of the atoms ought to be whole numbers. When actual measurements are made, it is even more obvious that they are no such thing. Out of such contradictions comes scientific progress.

After much juggling of figures during the 19th century, two schools of thought about atomic weight developed in opposition to each other. One leaned to the theoretical side, and called the atomic weight of hydrogen one. That gave fractions in the atomic weights of the other elements. It was thought that the fractions must result from experimental inaccuracy. The other school of thought leaned to the practical side, and standardized on 16.00 as the weight of oxygen. This made all the other weights more nearly whole numbers, but made H = 1.008. The practical party prevailed, and atomic weights are now based on O = 16. The current explanation of the enigma came much later, from an unexpected quarter.

Spectra

To distinguish between the myriad substances studied by chemists, every unusual property is eagerly catalogued. Certain salts, when a bit of them is held on a wire in a colorless flame, color the flame yellow, orange, red, blue or green. The colors make distinctive tests for the metals that form those salts. It occurred to Bunsen and Kirchhoff, a famous team of chemical explorers, in 1859, that they

could learn more about those colors if they spread them out into a spectrum. The compact little apparatus they built and named the spectroscope has proved a much more powerful tool even than they dreamed, for every element was found to have a bright-line spectrum as distinctive as a finger-print, with characteristic lines not only in the visible part but in the infra-red and the ultra-violet

as well, as far as our recording methods can trace. The whole spectrum, visible and invisible, has been charted and all known lines numbered.

Characteristic spectra of the elements range in complexity from sodium with a single pair of yellow lines to iron with hundreds of lines throughout all frequencies. As soon as it was known that light from a hot source would reveal the incandescent

metals glowing there, chemists of the heavens analyzed the stars. There they found much that was familiar, some things new, including the element Helium, named for the sun, later located on earth. From spectra they learned not only the constitution of the stars but also their temperatures, their ages, the rate they travel and the direction they move relative to the earth, and how to tell suns from nebulae.

Atomic Numbers

For chemistry, the spectroscope not only identified the elements, it counted them. At first there seemed no regularity of any sort in spectral lines, but in 1914 Moseley, a young British chemist, observed a certain pattern of lines in the X-ray spectra which recurred in element after element, but in a different region of the spectrum for each. It was a simple matter to arrange these spectra in the order of the atomic weights of their elements. Every element showed

the characteristic group at a wave frequency proportional to its place in that order. A gap in the table would show up in the spectrum series like a missing tooth. The two or three cases of elements thrown out of their logical places in the Periodic Table by anomalous atomic weights were corrected by the spectrum series. It was then possible to start with H = 1 and assign atomic numbers to all the elements, known and unknown. Thus they were counted.

The Periodic Table

The basis of the periodic table is just the list of all the elements arranged in the order of their atomic weights. Mendeleeff's genius showed itself in his recognition of where to cut the list, and in his interpretation of the irregularities which he found.

After hydrogen the arrangement of the first two series is easy. The properties of the elements change gradually from lithium and sodium, which are the most alkaline, through beryllium and magnesium, less basic, to boron and aluminum, with intermediate properties. Then carbon and silicon begin the non-metals, nitro-

gen and phosphorus, which form acids, come next, oxygen and sulfur are definitely more negative, and the two series end with the halogens fluorine and chlorine, most negative of all.

The following series, beginning with potassium, fits the scheme well enough at first, and at the end arsenic, selenium and bromine close the series by corresponding with their analogues phosphorus, sulfur and chlorine. But the long series of metals in between, with the triad iron, cobalt and nickel in Group VIII, is one of the inner rhythms of

the table which puzzled lesser arrangers before Mendeleeff.

The second long period then corresponds element for element with the series preceding it, only to have the rhythm again interrupted by the puzzling set of elements known as the rare earths. It would surprise no one if the elements then branched off and formed new patterns, but no, back swings the rhythm of resemblances to form another Group VIII triad with osmium, iridium, platinum. The march of the elements goes on to gold, known as an analogue of copper and silver since the beginning of time, and so on to complete the 5th period.

The mystery of the elements is only deepened in period 6 by radioactivity, which adds the most amazing physical properties to elements that still retain the commonplace chemical properties expected of them.

Mendeleeff was so sure of the rhythms of the elements which he knew by observation that he predicted the properties of the elements he felt sure must be missing from the table and stated that they were yet to be discovered. He lived to see a number of them found, fulfilling his prediction most accurately. Others have been found since his day.

What he could not predict were those of no combining power. The discovery, at the end of the nineteenth century, of a set of new elements with absolutely no chemical

properties threatened for a moment to jeopardize Mendeleeff's periodic law. Ramsay therefore watched with some anxiety the determination of atomic weight of his new gases, and was gratified to find them falling regularly into place among the older elements, bringing new harmony into the periodic table.

But the most startling phenomenon of the table is the fact that the list of known elements breaks off in the middle of a series. Announcement of the discovery of Element 93 caused no shock. There is no reason why Uranium should be the last element. But if we have not progressed far in the direction of finding heavier elements, at least we know why. Those elements are obviously radioactive. The earth may at one time have been full of them, for all we know, but if so they must have disintegrated into something simpler long since.

It is fascinating to conjure up the possibilities of these heavier elements and their compounds. Are they the stuff that makes up those dwarf stars the astronomers tell us about, whose substance is so dense that a bit of it the size of a pea would weigh a ton? We shall probably never know. We are creatures of the lower end of the list of elements.

In the December issue, Mrs. Davis will explain the various states of matter—solids, liquids, gases, smokes, greases and go.

The fir plywood industry, now turning out enormous quantities of plywood for war and other uses, has established a research foundation intended to devise or uncover forest products separate from lumber, plywood and pulp.



From the Merck Review

"Say Doc, those vitamins you've been giving me are wonderful—
I not only feel full of pep but I also learned the alphabet!"



Underwood and Underwood Photo

Pauline Beery Mack

**Pauline Beery Mack Is National Leader
in Better Nutrition and Education**

Chemist, Research Director, Editor

• PAULINE BEERY MACK is director of the Ellen H. Richards Institute of The Pennsylvania State College and as such she is a nationally influential leader in the great task of providing better food, clothes and shelter for the people.

Chemist, research director, and dynamic catalyst in the educational community of Pennsylvania's state center for higher education, Dr. Mack found time during busy years of teaching and research to found and edit the Chemistry Leaflet.

She created and nurtured this journal in order that students in the secondary schools and in the lower years of college might have something to connect everyday life with the pages of their textbooks. So well did her journal perform its function that it grew from what was originally a leaflet in fact to a full-fledged magazine.

The nutrition research under Dr. Mack's guidance, planning and inspiration grew also and now a staff of over 60 scientists, nutritionists and other workers are engaged upon various aspects of the Pennsylvania mass studies in human nutrition. War increased the tempo and the urgency of these thorough studies upon hundreds of children and adults. Increased co-operation from the state government and from other research organizations added to the results and usefulness of the research.

As Dr. Mack's offices and laboratories upon the pleasant, rolling Pennsylvania State campus grew busier, as the studies multiplied the inquiries and examinations in homes, factories and medical institutions in Philadelphia and elsewhere, Dr. Mack found herself confronted with a growing intellectual family that demanded more time than even she could find in the 24 hours of the day.

Not that she loved one the less, her research or her journal. Both were precious to her. The question was: Through which could she make the greater contribution to a better world?

Her scientific research and her inquiries into the best food for strong and healthy bodies and minds must go on, obviously. She must continue this service.

So it is that the journal that she has edited for 17 years is being adopted, with Dr. Mack's blessing, into the Science Service family of activities.

So "Pauline G. Beery, Editor," as it has appeared on past issues, becomes upon this issue's masthead: "Pauline Beery Mack, (Editor 1927-1944), Consulting Editor."

Because someone else now has the last say with a figurative blue-pencil, these notes on Dr. Mack can be published.

A few more notes of interest to

old and new friends of this publication:

Dr. Mack's parents, Mr. and Mrs. John P. Beery, collaborated in the editing and managing of the Chemistry Leaflet. Until his death early this year, Mr. Beery worked with Dr. Mack in the editorial details, and until recent months Mrs. Beery participated in the subscription and accounting details.

The Pennsylvania State College and its Department of Chemistry, headed by the nationally known organic chemist, Dr. Frank C. Whitmore, looked upon Dr. Mack's editorial activities with encouragement and co-operation, and the staff of the Ellen H. Richards Institute of The Pennsylvania State College assisted in the editing of the Chemistry Leaflet. In past years, the Chemical Foundation and the American Institute of the City of New York have given their support to the publication.

A major Chemistry Leaflet collaborator through its years has been Dr. Warren B. Mack, head of the department of horticulture at The Pennsylvania State College, the member of the Mack family who is as interested in the best ways to grow food as his wife is in the best foods for good nutrition. Dr. and Mrs. Mack are one of those husband-wife teams of scientists that have contributed so much to research. Fertile fields of the college's experimental farm show the results of his science, and woodcuts are his recreation. He has the unusual distinction of election to the National Academy of Design and to the presidency of the

American Society of Horticultural Science both this year.

Dr. Pauline Beery Mack has had a deep interest in any effort that explains science and inspires a scientific attitude among the people, particularly among youth. Along with her editorial service, she pioneered in stimulating science clubs in high schools. She organized the Student Science Clubs of America which later were brought together with the Science and Engineering Clubs of the American Institute of the City of New York, which in turn formed the nucleus for Science Clubs of America, now a Science Service activity with over 5,000 clubs affiliated. Thus it is that these two activities—magazine and clubs—are marching along together, fortunate in having had the benefit of the helpful labors of Dr. Mack.



The Activities of Science Service

are directed toward presenting science in all its aspects to the people of the world. Through newspapers, radio, magazines, experimental kits and other media, science is interpreted and diffused.

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SCIENCE NEWS LETTER (weekly) summarizes the march of science for scientists and non-scientists alike. This unusual magazine-style report brings you the newest information on changes and progress in all fields of science and invention, reporting meetings, summarizing journal articles and reviewing books. \$5 a year.

OVERSEAS SCIENCE NEWS LETTER (monthly) takes the latest in science to our fighting men overseas and to scientific good neighbors in foreign lands. Offset printed on thin paper in reduced size, it is sent to U. S. fighters by first class mail for \$1.25 per year.

THINGS OF SCIENCE (monthly) consists of a box or bulky envelope of science exhibits and experimental materials. These new or unusual, natural or fabricated products are accompanied by complete explanations, suggested experiments and museum-style legend cards for each specimen included in the unit. \$4 per year, 50 cents a unit.

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Strategic Minerals	Meteorite	Sulfur	Plywood	Prince	Spice
Bread	Plant	Treated Hormones	Oil Seeds	Rupert's Drops	Rubber Plants
Vitamins	Fire Psy- chology	Wood and Cloth	Unusual Paper	Felt	Plastic Pilot Aids
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